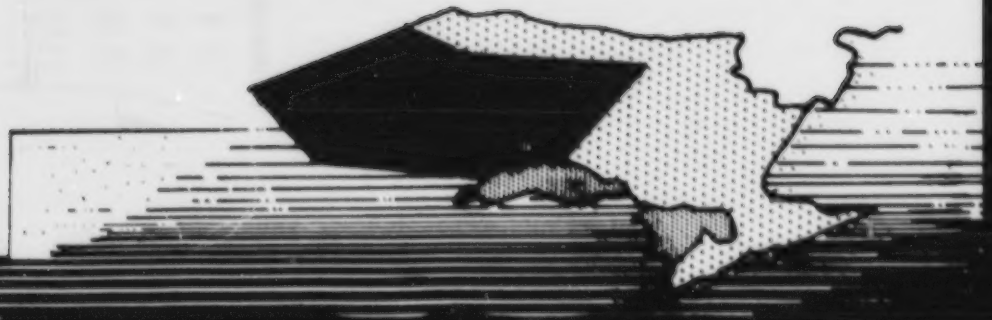

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NORTHWESTERN ONTARIO FOREST TECHNOLOGY DEVELOPMENT UNIT

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A COST ANALYSIS OF THE COMBINED BULK LIFT - AREA BASE PLANT SYSTEM

by

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EXECUTIVE SUMMARY

Bulk lifting of nursery seedlings and area base planting are two systems that complement one another. In Ontario, these systems have not received wide use and have not been integrated operationally. This report describes an evaluation of the economics and practicality of a combined bulk lift and area base planting system. Bulk lifting refers to harvesting seedlings from nursery beds and packing them directly into containers for shipment to the planting site without sorting, culling, counting or bundling. Area base planting can be defined as payment for planting work on an area or per hectare basis instead of on a per tree piece work or hourly basis.

Two bulk lifts were conducted at the Thunder Bay Forest Nursery using a mechanical seedling belt harvester during the 1990 spring and fall seedling lifts. The area base planting site was located near South Girvan Lake in Nipigon District.

Cost savings for the fall bulk lift were estimated to be $15.38/1000 seedlings, 29 percent of the cost of the fall conventional lift. Assuming the nursery were to lift 50 percent of their stock production target (7.5 million seedlings) using the mechanical bulk harvester an annual cost saving of almost $119,000 could be attained. The capital cost of the harvester was not included in this cost analysis. Based on the productivity figures for the fall bulk lift, up to 6 additional mechanical harvesters and 84 workers would be needed to harvest the 7 million seedlings lifted in the conventional fall harvest in the same time period. This assumes no major mechanical breakdowns.

Mechanical problems with the belts on the bulk harvester during the spring bulk lift resulted in extended downtime and thus a manual bulk lift was necessary. Additional data on the mechanical bulk lift were collected in the fall of 1990. Although some mechanical problems did occur during the fall bulk lift, sufficient productivity data were collected to obtain a reliable estimate of operating costs. Approximately 178,000 seedlings were harvested in 17.4 hours with 5.2 hours (29.9 percent downtime) lost due to mechanical breakdowns.

Levels of seedling cull per box were assessed to determine the percent of substandard seedlings potentially being shipped to the planting site. Cull levels averaged 8 percent for the fall bulk lifted stock. Less than a third of the cull was the result of physical abnormalities or damage attributable to the mechanical bulk harvester. The majority of the cull was due to deformed root systems or inadequate height. It should be noted that the bulk harvesting trial was conducted in transplant beds that were not tended or cultured to accommodate this method of harvesting. Cultural and tending practices (eg. removal of small seedlings during the handweeding operation) could be modified to reduce the incidence of this type of cull. Boxes of conventionally lifted stock may contain up to approximately 5 percent cullable seedlings, even after sorting and grading.

Nursery soil was not adequately removed from the roots of the mechanically bulk lifted seedlings. As a result, the boxes of mechanically harvested seedlings weighed significantly more than boxes of conventionally lifted stock. Excessive soil means fewer seedlings per box and increased shipping costs. Heavier box weights may also increase the risk of work related back injuries and the risk of boxes of seedlings being crushed while in transport. In addition, significant

quantities of fertile soil may be shipped to the field and hence lost from the nursery. Modifications to the soil removal system on the mechanical bulk harvester are planned to help alleviate this problem.

Full benefits of area base planting can only be realised if planters are paid in proportion to the amount of area satisfactorily planted. In the area base planting portion of this project, the contractor, although signed to an area base contract, opted to pay his planters on a per tree basis. As a result, a complete assessment of the area base planting system was not possible. Based on cost information from previous area base plants in Ontario, it was determined that there was little cost difference between tree planting operations using the two methods of payment. The relative cost of area base planting projects can be expected to decrease as contractors become more experienced with this planting payment system and submit lower and more competitive bids.

It is recommended that the province adopt a combined bulk lift - area base planting program as a portion of the annual silviculture program. This program could be expanded with the dollars saved in production and lifting costs at the nursery. It is also recommended that contracts for area base planting stipulate that tree planting contractors pay planters by the unit area so as to take full advantage of the benefits of such a system. A training workshop for contractors and MNR staff should be organized which outlines the benefits of area base planting and how to conduct an area base plant.

Despite the problems encountered it was concluded that the bulk lift - area base planting system is a logistically and economically viable alternative to the conventional lift - per tree planting payment system currently in use in Ontario.

TABLE OF CONTENTS

Page

EXECUTIVE SUMMARY i

LIST OF TABLES v

LIST OF FIGURES vi

LIST OF APPENDICES vii

Acknowledgements viii

INTRODUCTION 1

Background Information and Rationale 1

Bulk Lifting 1
Description of Lifting Procedure 7
Area Base Planting 9

Project Goals and Objectives 12

METHODS 12

Lift Monitoring 13

Productivity 14
Time Study 15
Box Counts and Cull Assessment 15

Area Base Planting 16

Area Description 16
Planter Productivity 17
Planter Opinion 17

RESULTS 18

Seedling Lift 18

Conventional Lift 18

Productivity 18
Time Study 18

Bulk Lift 20

Productivity 20
Time Study 24

Box Counts and Cull Assessments 25
Nursery Assessment Plots 28

Area Base Plant 29

Packing Time Data 29
Questionnaire Responses 29

DISCUSSION 30

Cost Model for Bulk Lift - Area Based Plant System 30

Bulk Lift Versus Conventional Lift 30
Shipping Costs for Bulk Lift Versus Conventional Lift 35
Area Base Versus Conventional Tree Planting 36

Seedling Lift 38

Conventional versus Bulk Lift 38
Time Study 40
Box Counts and Cull Assessments 40

Area Base Plant 42

Packing Times 43
Questionnaire Responses 43
Problems Encountered with the Area Base Planting Project . . 44
Limitations of the Study 47

CONCLUSIONS 48

RECOMMENDATIONS 49

LITERATURE CITED 50

LIST OF TABLES

		Page
Table 1.	Number of seedlings lifted from the two stock lots and compartments and their in-bed density.	13
Table 2.	Daily seedling production during the 1990 spring and fall conventional lifts at the Thunder Bay Forest Nursery.	19
Table 3.	Number of seedlings per box and cull rates for the 1990 spring and fall bulk lifted stock at the Thunder Bay Forest Nursery.	26
Table 4.	Cost of the 1990 spring and fall conventional seedling harvests at the Thunder Bay Forest Nursery.	31
Table 5.	Summary of costs for the 1990 spring and fall bulk lifts. . .	32

LIST OF FIGURES

		Page
Figure 1.	The Egedal single-row belt harvester at Orono Nursery (Courtesy: G. McLeod, Orono Nursery).	3
Figure 2.	Harvesting a row of seedlings with the Egedal single-row seedling harvester at Orono Nursery. (Courtesy: G. McLeod, Orono Nursery).	3
Figure 3.	The Hovey eight-row seedling belt harvester.	5
Figure 4.	Seedling harvest with the Hovey eight-row seedling belt harvester at the Thunder Bay Forest Nursery during the 1990 spring seedling lift.	5
Figure 5.	Seedlings travelling up the belts of the Hovey eight-row seedling belt harvester at the Thunder Bay Forest Nursery during the 1990 spring seedling lift.	6
Figure 6.	Packing seedlings in tubs during the test run with the Hovey 8-row seedling belt harvester during the 1990 spring seedling lift at the Thunder Bay Forest Nursery.	6
Figure 7.	Vertical Root Pruning with a rolling coulter type root pruner at the Thunder Bay Forest Nursery in the spring of 1990. . .	8
Figure 8.	End view of the coulter type vertical root pruner used at the Thunder Bay Forest Nursery during the 1990 spring seedling lift.	8
Figure 9.	Change in productivity of the fall bulk lift based on the number of seedlings harvested in five minute intervals in compartment 58 on October 24, 1990.	23
Figure 10.	Change in productivity of the fall bulk lift based on the number of seedlings harvested in five minute intervals in compartment 58 on October 26, 1990.	23
Figure 11.	Change in productivity of the fall bulk lift based on the number of seedlings harvested in five minute intervals in compartment 48 on October 26, 1990.	24

LIST OF APPENDICES

		Page
APPENDIX I	Nursery Grading and Culling Rules (from Schedule A of the Seedling Lifting Contract)	51
APPENDIX II	Questions Asked to Tree Planters and Their Responses .	54
APPENDIX III	Schedule 'A' From the Nipigon Area Base Planting Project Contract	57
APPENDIX IV	Daily Account of Harvester Operating Times and Description of Mechanical Breakdowns For the Fall 1990 Bulk Lift	68
APPENDIX V	Seedling Counts and Cull Assessment Data For the 1990 Fall Bulk Lifted Stock From Compartments 48 and 58 . .	71
APPENDIX VI	Seedling Counts and Cull Assessment Data For The 1990 Spring Mechancially and Manually Bulk Lifted Stock . .	75
APPENDIX VII	Spring and Fall Conventional Lift Costs and Cost Model For The Conventional Lift - Per Tree Plant	78
APPENDIX VIII	Spring and Fall Bulk Lift costs and Cost Model For The Combined Bulk Lift - Area Base Plant	85
APPENDIX IX	Fall Bulk Lift Costs for Compartments 48 and 58	93
APPENDIX X	Convention and Area Base Planting Costs	98

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INTRODUCTION

Bulk lifting refers to harvesting seedlings from nursery beds and packing them directly into containers for shipment to the field without sorting, culling, counting or bundling. Area base planting is defined as payment for planting work on a per hectare basis instead of on a per tree piece work or hourly basis (Brinkman 1989). These two operational systems complement one another, although to date, they have been treated independently in Ontario. The purpose of this study was to examine the feasibility on an operational level of a combined bulk lift - area base plant.

Background Information and Rationale

Bulk Lifting

Bulk lifting reduces both the amount of seedling handling and the manpower required in the lifting operation. The decrease in seedling handling reduces the risk of seedling damage (Trewin 1976) and may result in healthier seedlings being shipped to the field. The lower manpower requirements associated with bulk lifting may also result in reduced lifting costs at the nursery.

Bulk lifting can be done manually or mechanically. Two mechanical harvesters that have been used for mechanical bulk lifting are the modified potato-harvesters of the GREYCO type and the belt harvester. The GREYCO type harvester was used in a few of the larger nurseries in New Zealand until the early 1970's (Trewin 1976). This harvester undercuts the entire seedbed and lifts the seedlings still rooted in the soil onto a vibrating chain conveyor (Trewin 1976). The chain conveyor shakes the soil from the roots and delivers the seedlings without the soil to the rear of the machine where they are collected en masse in crates or sorted by hand (Trewin 1976). According to Trewin (1976) a crew of 13 could lift and pack 300,000 seedlings per day.

However, he also added that this machine does not reduce the amount of handling required after the seedlings are lifted or shorten the time of seedling exposure.

Belt harvesters were first used operationally in New Zealand in the late 1960's (Trewin 1976). These harvesters could efficiently harvest large numbers of seedlings in a short period of time. But according to Trewin (1976), the efficiency of the collecting and packing procedures needed to be increased in order to fully utilize the benefits of the belt harvester. Belt harvesters have the advantage over other harvesters in that each tree is lifted individually and the trees remain separated as they travel up the belts (Trewin 1976) reducing the amount of root intertwining.

The development of belt harvesters in Ontario also began in the late 1960's and early 1970's. At Kemptville Forest Nursery attempts were made to modify a belt harvester used for harvesting carrots to harvest tree seedlings (R. Klapprat[1], pers. comm. 1990). The belt harvester was modified by the Mechanical Development Unit of the Ontario Forest Research Centre in 1976 and became the basis for the design of belt harvesters used in Ontario today (A. Citro[2], pers. comm. 1990). Belt harvesters can have 1 or more lifting heads. A single row belt harvester was brought into Ontario from Europe in the early seventies and was used at St. William's and Orono Forest Nurseries (Figures 1 and 2). However, the demand by districts for bulk lifted stock was very low and this machine sat idle from 1985-1990 (G. McLeod[3], pers. comm. 1990).

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[1] Nursery Superintendent, Thunder Bay Forest Nursery, Ontario Ministry of Natural Resources.

[2] Nursery Stock Production Specialist, Forest Resources Group, Ontario Ministry of Natural Resources.

[3] Nursery Superintendent, Orono Nursery, Ontario Ministry of Natural Resources.

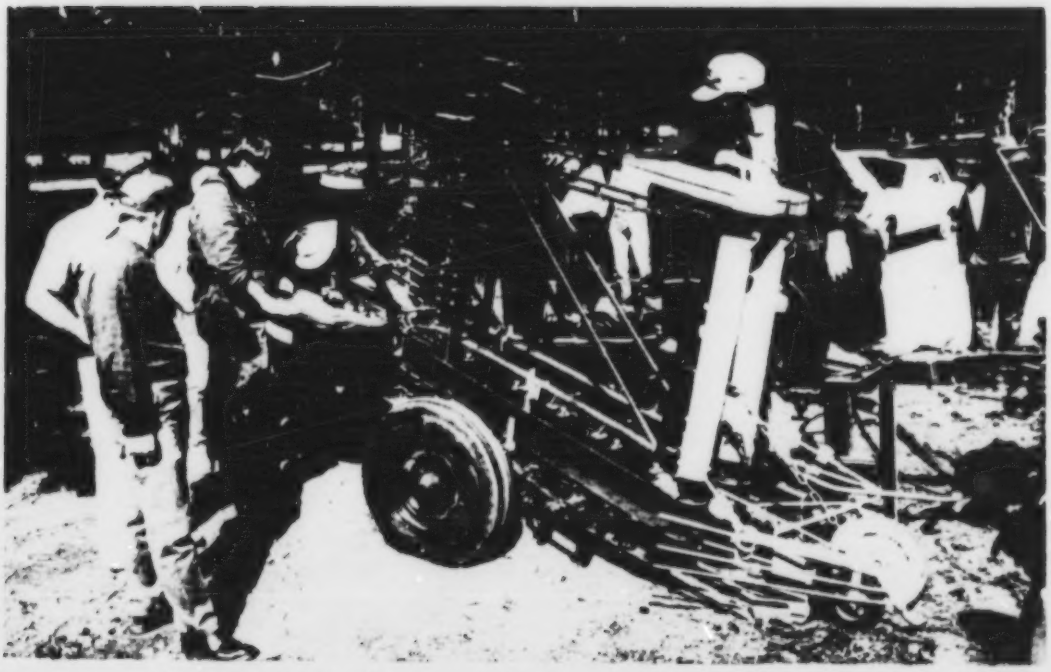

Figure 1. The Egedal single-row belt harvester at Orono Nursery (Courtesy: G. McLeod, Orono Nursery).

Figure 2. Harvesting a row of seedlings with the Egedal single-row seedling harvester at Orono Nursery. (Courtesy: G. McLeod, Orono Nursery).

Bulk lifted stock is not compatible with conventional tree plants because the seedlings are not sorted and an accurate count of the seedlings per box is not available. Therefore, field staff must count seedlings to assess the planters' performance.

At Swastika Forest Nursery in northern Ontario, an eight-row belt harvester was fitted with mechanical counters (Cameron 1988). With this machine it is necessary to calibrate the counting mechanism for the required number of seedlings prior to use. Double and triple seedling counts are common as seedling branches and stems can trigger the counter (Cameron 1988). In trials conducted at the Swastika Forest Nursery in 1987, counters were set between 270 and 285 to obtain an average of 250 seedlings per bag. Both the stock type and the forward speed of the harvester influenced the reliability of the seedling counts. Calibration of the counters was a time-consuming process which reduced operating time. Problems with the seedling counters as well as other mechanical problems occurred in the spring of 1990, and as a result, the belt harvesters were not used (Wayne Nakamura[4], pers. comm., 1990).

Two six-row belt harvesters were purchased by the Thunder Bay Forest Nursery in 1979 and were in operation from 1980-83 (R. Klapprat, pers comm. 1990). In 1984 the nursery began growing seedlings in eight rows instead of six and in 1989 two Hovey eight-row seedling belt harvesters were purchased (Figure 3). A trial run of the harvesters was conducted during the fall lift of the same year. In the trial run, seedlings were loaded into plastic tubs and transported to the shipping barn for sorting, culling, counting and packing in boxes with a polyethylene insert prior to placement into cold storage. This belt harvester was used in the bulk harvest trials during the 1990 spring and fall lifts at the Thunder Bay Forest Nursery (Figures 4-6).

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[4] Nursery Superintendent, Swastika Forest Nursery.

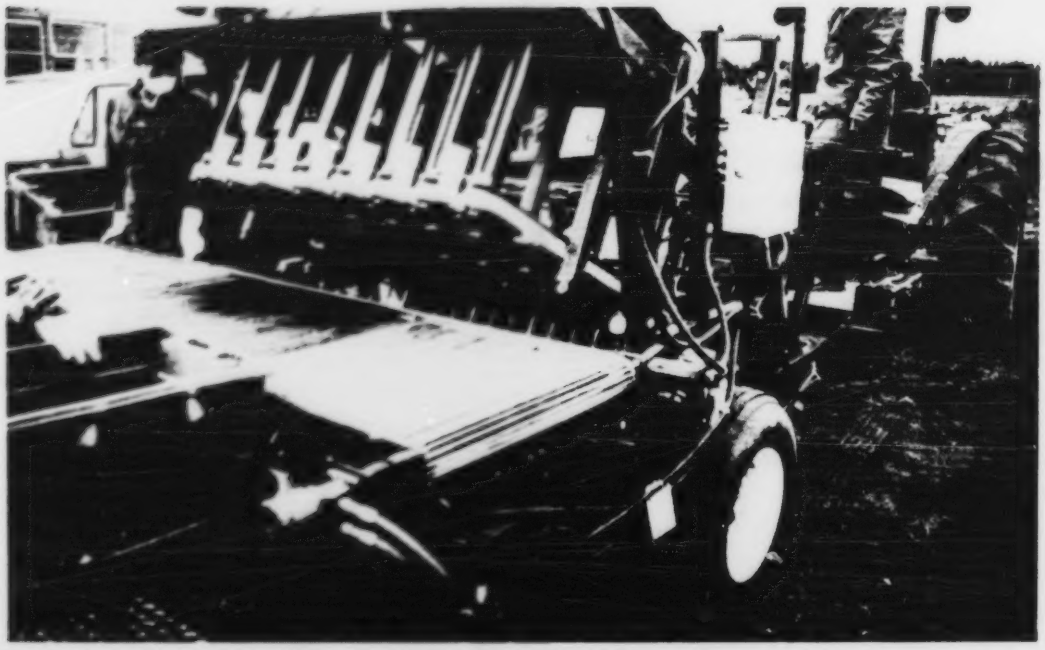

Figure 3. The Hovey eight-row seedling belt harvester.

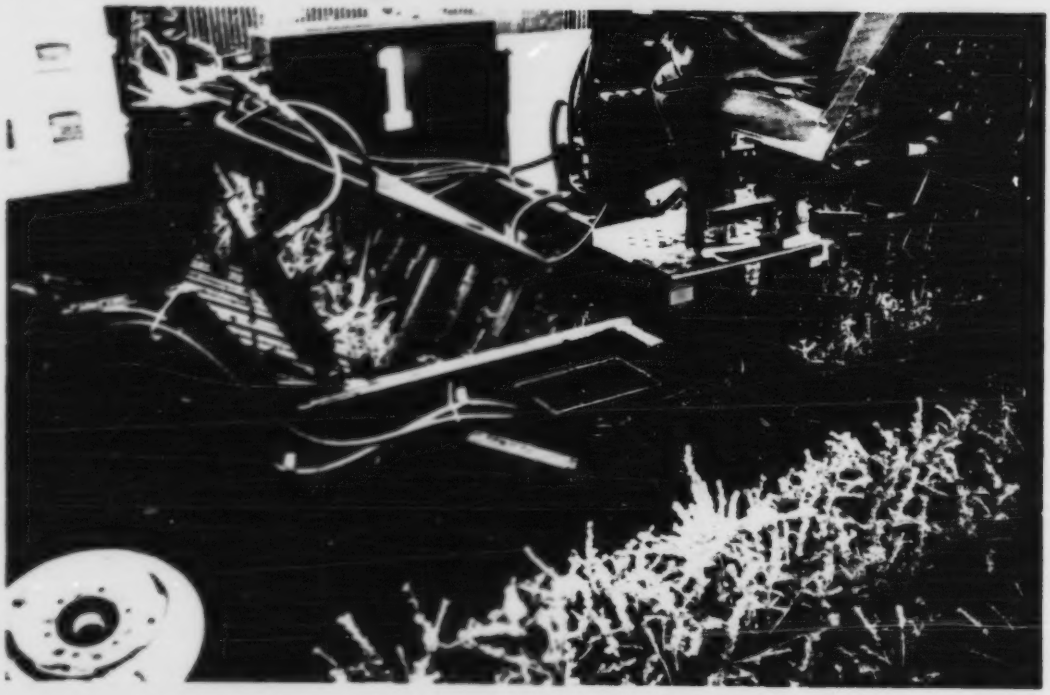

Figure 4. Seedling harvest with the Hovey eight-row seedling belt harvester at the Thunder Bay Forest Nursery during the 1990 spring seedling lift.

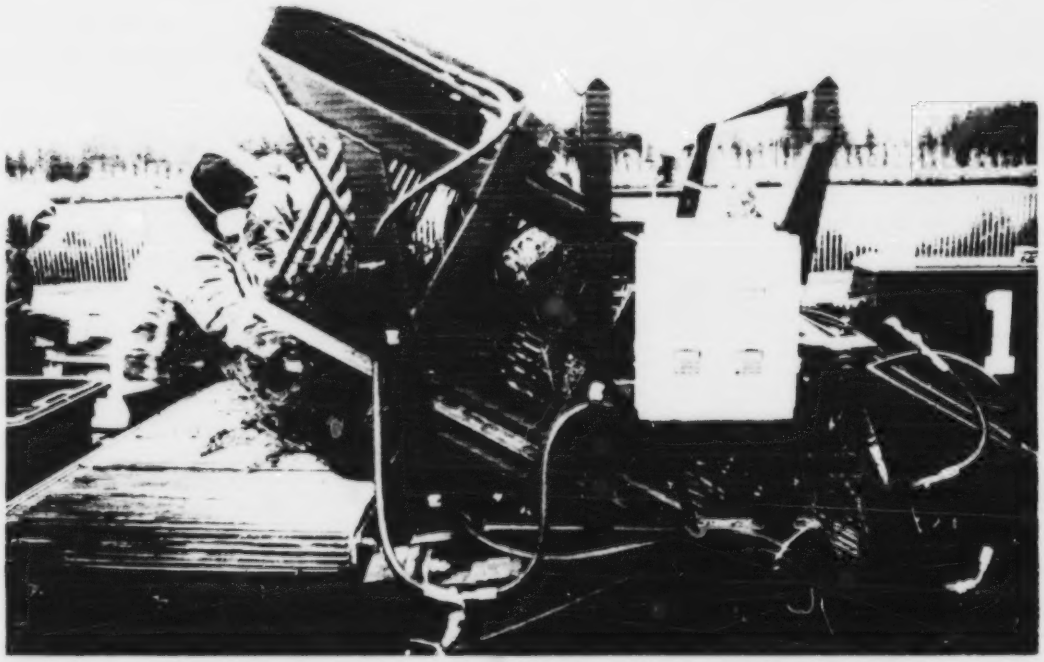

Figure 5. Seedlings travelling up the belts of the Hovey eight-row seedling belt harvester at the Thunder Bay Forest Nursery during the 1990 spring seedling lift.

Figure 6. Packing seedlings in tubs during the test run with the Hovey 8-row seedling belt harvester during the 1990 spring seedling lift at the Thunder Bay Forest Nursery.

Description of Lifting Procedure

In a conventional seedling harvest at a bareroot tree nursery, seedlings are undercut and loosened from the soil by an Egedal-type lifter. Workers follow the machine, manually remove the seedlings from the ground, shake them to remove soil from the roots. Cull trees are removed according to standards supplied by the nursery, bundled by 10's or 25's, and secured by elastic bands. Bundles are either packed directly into bags or boxes or are taken to a packing station where the roots of the seedlings are trimmed prior to packing. The bags or boxes are then closed and transported to a cooler for storage until the seedlings are required for planting. This procedure is quite labour intensive and can involve over 200 manual workers at the nursery during a normal work day. This results in a high variable cost but low capital cost for the seedling lift operation. Conventional lift production levels at the Thunder Bay Forest Nursery during the 1990 spring and fall lifts averaged 550 000 and 767 000 seedlings lifted by 170 and 227 manual workers per day (7.5 hours), respectively.

For a bulk lift, seedlings are vertically and horizontally root pruned (Stoeckeler and Jones 1957) in a separate operation approximately two to three weeks prior to the scheduled lift date. Vertical root pruning is done using a rolling coulter type root pruner (Figure 7 and 8). Immediately prior to lifting, the seedlings are undercut to loosen the soil around the roots.

At the Thunder Bay Forest Nursery seedlings are removed from the ground using an eight-row belt harvester pulled by a tractor. The belt harvester has eight lifting heads, each comprised of a pair of counter-rotating belts oriented at an angle to the ground (Figure 4). Lifting heads grip the seedlings near the root collar and remove them from the ground. Belt speed is faster than the forward motion of the harvester so the seedlings within the row are separated

Figure 7. Vertical Root Pruning with a rolling coulter type root pruner at the Thunder Bay Forest Nursery in the spring of 1990.

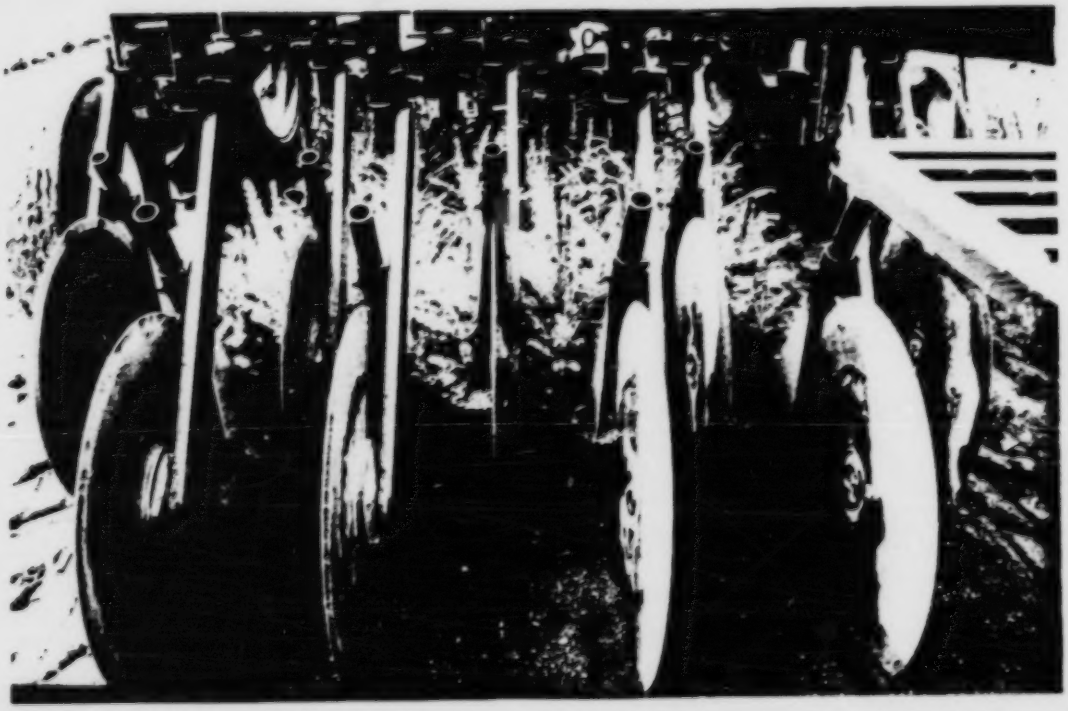

Figure 8. End view of the coulter type vertical root pruner used at the Thunder Bay Forest Nursery during the 1990 spring seedling lift.

from each other. As the seedlings move up the belts, an oscillating metal frame under the seedlings removes excess soil from the roots. When the seedlings reach the upper end of the belt they are dropped onto a chain conveyor moving at a 90° angle to the belts' direction of travel. The seedlings are oriented in a single direction by hand and placed in poly-lined boxes. When a box is full it is placed on the ground, sealed and transported to the cooler.

This process requires approximately 8 to 12 workers per harvester, far fewer than for a conventional lift. Variable costs for this operation are relatively low compared to the conventional seedling lift while the fixed or equipment costs tend to be higher. At Swastika Forest Nursery, where bulk lifting has been done for several years, an average of 180 000 seedlings were lifted in 1987 during a 7.67 hour day by a crew of ten (Cameron 1988).

Area Base Planting

Area base planting was introduced in the Western United States in the early 1970's, where it is now the predominant form of contract planting (Brinkman 1989). The first area base plant in Canada was conducted by MacMillan Bloedel Ltd. in 1979 on a 60 ha site where natural regeneration was abundant. The area base plant system is now used extensively throughout British Columbia and because of its success may become the required planting method in that province by 1993 (Guthrie 1990). In Ontario, area base planting was first attempted by the Ministry of Natural Resources in Cochrane District in 1984 and 1985, Gogama District in 1986 and Thunder Bay District in 1987 (Guthrie 1990) and by Great Lakes Forest Products (now Canadian Pacific Forest Products) in 1986. In 1989, three area base planting projects were conducted in Ontario by Brinkman and Associates in North Bay, Nipigon and Chapleau Districts.

Area base planting has several advantages over conventional tree planting (Brinkman 1989, Guthrie 1990). One of the major advantages is that approximately 10 to 15 percent more area can be covered with the same number of seedlings as compared to a per tree payment system (Lehane 1988). This has resulted in a cost savings of close to $100,000 per year for Fletcher Challenge Canada (Lehane 1988).

Increased area coverage is a result of several factors. These include, 1) increased utilization of available planting spots resulting from a better planting pattern, 2) removal of the tendency to plant seedlings in fringe areas that should not be planted, 3) removal of the tendency to plant seedlings too close together, 4) removal of the tendency of planters to cull heavily and not plant marginal seedlings, and 5) removal of the incentive for planters or contractors to stash trees (Brinkman 1989). It must be stressed that these advantages can only be realized if planters are paid by the area and not by the tree.

For the three area base planting projects conducted in Ontario in 1989 an average of 14.45 percent of the issued seedlings were surplus (Brinkman 1989). Brinkman (1989) recommended that for future area base plants, overflow or contingency areas should be located to accommodate the surplus seedlings. Better techniques for estimating seedling requirements could also be employed.

The main benefit to the contractor of area base planting is that there is a greater degree of co-operation between the planters and supervisors (Guthrie 1990). With per tree planting, efforts of the supervisor are directed at encouraging planters to lower planting densities, honour naturals and strive for better spot selection (Lehane 1988). Planters tend to maximize profit by planting densely on easy ground, avoiding difficult areas and putting trees into marginal

planting sites (Lehane 1988). With area base planting, planters will try to cover as much area as possible with a given number of trees in order to maximize their earnings. Layton (1987) states that area base planting provides the necessary incentive to search for plantable spots while maintaining production levels and quality. Naturals and unplantable areas are seen as bonuses rather than hindrances.

Prescriptions for area base planting must be accurate to ensure the number of seedlings requested is neither more nor less than required to plant the desired area (Guthrie 1990). Prescriptions must include minimum and maximum spacing, target densities and estimates of frequency and distribution of naturals, unplantable spots, and patches to be excluded from the project area to get accurate and competitive contract bids (Guthrie 1990). Since area base tree planters are being paid by the amount of ground covered, they will try to plant as few seedlings as possible while staying within the contract parameters. Von Hahn (1988) recommends that the minimum planting density be set close to the actual target density because contractors generally plant about 93 percent of the density prescribed.

Area base planting can be applied to any planting site, but benefits increase with the difficulty of the planting site (Lehane 1988). The most significant savings occur on sites where planting spots are few or unevenly distributed or where natural regeneration or partial stocking exists (Lehane 1988). Brinkman (1989) recommended avoiding areas in which planting spots are pre-defined through site preparation.

With area base planting, the main concern is with the total area planted. The total number of trees, the number of trees in a box, tray or reefer van, or even the number of trees that a planter plants is somewhat irrelevant (Guthrie

1990). This aspect of area-base planting lends itself to the use of bulk lifted stock.

Project Goals and Objectives

The goals of this project were:

1) To evaluate the comparative economics and efficiency of a combined bulk lift and area base plant as an operational system. Area based planting efficiencies were only evaluated as they were affected by bulk lifting.

2) To identify the relationship between bulk lifting and area based planting, potential problems and solutions.

These goals were evaluated in terms of the following objectives:

1) Determine feasibility of bulk lifting in the nursery based on cost, cull factors, packaging time, inventory methodology, mechanical damage and equipment limitations.

2) Identify special requirements for contracting area base planting using bulk lifted stock.

3) Complete an economic analysis of the combined bulk lift - area base plant system, and make inferences on potential economic impacts of changes to the system.

METHODS

This project consisted of a mechanical bulk seedling lift at the Thunder Bay Forest Nursery and an area based plant in Nipigon District. The methodology was designed to obtain productivity and cost information on the combined bulk lift - area base plant system so that comparisons could be made with the standard system currently in use in Ontario.

Lift Monitoring

The 1990 contract spring tree seedling lift at the Thunder Bay Forest Nursery consisted of both a conventional lift and a bulk lift. Targets were 8 million seedlings for the conventional lift and 130 000 for the bulk lift. Black spruce G+2 Techniculture transplants were bulk lifted using the Hovey eight-row mechanical belt seedling harvester. Seedlings were vertically root pruned with a rolling coulter root pruner two weeks prior to the scheduled lift date. Problems with the harvester resulted in only 13 000 seedlings being mechanically bulk lifted. Approximately 77 000 seedlings were bulk lifted by hand, and this total of 90 000 seedlings represented 70 percent of the target.

Mechanical problems were corrected during the summer and the harvester was used during the 1990 fall lift. Lift targets were 7 million seedlings for the conventional lift and 180 000 seedlings for the mechanical bulk lift. The 180 000 black spruce G+2 Techniculture transplants were lifted from two adjacent compartments (Table 1). Seedlings were vertically root pruned in mid-September, approximately one month prior to the scheduled lift date.

Table 1. Number of seedlings lifted from the two stock lots and compartments and their in-bed density.

Compartment	Stock Lot	Number of Seedlings Lifted	Seedling Density number/lineal metre
58	890034	143 000	51
48	890033	37 000	64

Productivity

Lift productivity for both the spring and fall bulk lifts was determined by counting the number of full boxes of seedlings produced in a five minute interval. This was done repeatedly while the harvester was operating. These data were plotted over time to show trends in productivity as workers adjusted to the machine and to determine maximum productivity levels. Regression analysis was used to determine if these trends were statistically significant. The speed of the mechanical harvester was monitored by measuring the distance travelled over the same five minute interval as above. For the fall lift, the time required to harvest each bed of seedlings was measured and the total number of boxes produced per bed was counted. The number of contractor and MNR employees involved in the bulk lift was also recorded as was the number and types of equipment used.

Lift productivity for both the spring and fall conventional lifts was monitored by the Thunder Bay Forest Nursery staff and was determined by counting the number of boxes of seedlings as they were placed into cold storage at the nursery. The number of lifters, packers and support staff was also recorded as was the total time worked. The number of MNR employees involved in the conventional lift and their rates of pay were also noted. Total costs to the MNR for equipment and supplies associated with the conventional lift were supplied by the nursery as was the MNR's payment to the contractor. Contractor's costs were estimated using the productivity data and field observations of the numbers and types of equipment used. Equipment costs were based on monthly rates from local rental companies. Monthly costs were divided by 26 working days in a month (based on a 6 day work week) and multiplied by the number of days in which the equipment was used. As a result, contractor costs were approximations only.

Time Study

The length of time between undercutting the seedlings and placement of the full boxes of seedlings into the cooler was recorded in the spring for both the conventional and bulk lifts. For the conventional lift, the time elapsed was noted for each of the following events:

1) when the seedlings were removed from the ground and placed in plastic tubs,
2) when the plastic tub was full,
3) when the tub was picked up for transport to the packing station,
4) when the tub of seedlings reached the packing station,
5) when the seedlings were put in a box,
6) when the box was closed, and
7) when the box was put in the cooler.

This was done three times during the course of the spring lift. The same stock type (G+2 black spruce Techniculture transplants) was monitored for all three time trials.

For bulk lifted seedlings, timing started when the seedlings were undercut with the belly blade prior to lifting. The time was noted when the following events occurred:

1) when the seedlings were picked up by the mechanical belt harvester,
2) when the seedlings were placed in the box,
3) when the box was closed, and
4) when the box was placed in the cooler.

Box Counts and Cull Assessment

During the spring lift, 20 boxes of seedlings for both the hand and mechanical bulk lift were randomly marked for seedling counts and cull assessment. Ten bundles of seedlings from a box of conventionally lifted stock from the same compartment were counted and assessed for cull by nursery staff as part of their stock quality monitoring program. For the fall lift, 32 boxes of seedlings from the two compartments were marked for sampling. These marked

boxes were taken to the nursery lab where the seedlings were counted and cull assessments done. Seedlings were assessed for cull using the same standards as those outlined in the lifting contract (Appendix I). A t-test was used to determine if there were significnant differences in the number of seedlings per box between the two methods of bulk lifting in the spring bulk lift, and between the two compartments in the fall bulk lift.

For the spring lift, seedlings left in the field after the mechanical harvester had passed by were assessed to determine if 'acceptable' seedlings were being left in the field. This was not done for the fall lift as the missed seedlings were already being picked up by one of the manual workers.

Seedlings lifted in the spring, and showing visible evidence of where they were gripped by the belts of the harvester were outplanted at the Thunder Bay Forest Nursery. The damaged portion of the stem was marked for future assessment. These seedlings were excavated in the fall and stem cross-sections were examined for physical damage using a microscope.

Area Base Planting

Area Description

The area base planting site was located in the Auden Management Unit, Nipigon District, in the vicinity of South Girvan Lake (Basemap 502873). The planting area consisted of a total net plantable area of 283.9 ha, divided into 26 blocks ranging in size from 1.7 to 27.9 ha. The majority of the area (266.1 ha) had been site prepared in the fall of 1989 using the Bracke patch scarifier. The remaining 17.8 ha were not site prepared. There was little desirable advanced regeneration on the site following site preparation.

Three stock types were planted on the site. These included 200 000 jack pine container stock, 90 000 white spruce 2+2 bare root stock and 130 000 black spruce G+2 Techniculture transplants which were either 1) conventionally lifted, 2) hand bulk lifted, or 3) mechanically bulk lifted. A tree planting company was contracted to do the area base plant. The contractor began planting on May 14, 1990 and finished by June 15, 1990.

Planter Productivity

Planters were observed and timed as they were filling up their planting bags to determine if there were any differences in loading-up procedures of planters using bulk lifted versus conventionally lifted black spruce stock types. Planters were also observed to determine if they were counting trees as they loaded up. Counting trees is not required in area base planting.

Planters were instructed to cull bulk lifted stock at the load-up site. Types of trees the planters were culling was observed and recorded in order to determine the degree of adherence to the nursery culling rules.

Planter Opinion

As planters were loading up or resting they were questioned as to their opinions on area base planting and on the use of bulk lifted stock. The same questions were asked to each planter. A list of the questions asked is included in Appendix II.

RESULTS

Seedling Lift

The spring lift began April 23 and was completed May 11, 1990. The fall lift began October 15 and was completed October 31, 1990.

Conventional Lift

Productivity

Daily productivity varied throughout the course of the lift and was affected by seedling size, staffing levels and the weather (Table 2). During the spring lift, lifter production ranged from 576 to 936 seedlings per hour and averaged 735 seedlings per hour. Contractor employees were paid on a piece work rate of $15.00 per 1 000 seedlings for their first three days and were then paid $11.88/hour for the remainder of the contract. Each lifter was required to lift a minimum of 5 500 seedlings per day. There was also a bonus payment system for production above the 5 500 seedling minimum.

Lifter production during the fall lift ranged from 695 to 959 seedlings per hour and averaged 788 seedlings per hour. Contractor employees were paid similarly in both spring and fall (i.e. piece work initially, then hourly).

Time Study

For the spring conventional lift, the time elapsed between undercutting and when seedlings were placed in the cooler ranged from 88 to 117 minutes with an average of 106 minutes. Root exposure times ranged from 13 minutes to 46 minutes with an average of 30 minutes.

Weather conditions were variable between the three spring time trials. The temperature was generally cool, ranging from 1 to 6° C. Wind speed ranged from

Table 2. Daily seedling production during the 1990 spring and fall conventional lifts at the Thunder Bay Forest Nursery.

Date (M/D)	Number of trees lifted	Hours of Lifting	Number of Lifters	Number of Table Crew	Number of Support Staff	Number of Trees/ Lifter/ 7.5 hr day
Spring Lift						
04/23	484 530	7.5	89	60	13	5444
/24	587 830	7.5	90	64	13	6531
/25	525 190	8.0	114	56	13	4319
/26	576 830	8.0	98	55	13	5518
/27	392 560	4.0	143	42	13	5147
/30	891 230	8.0	119	39	13	7021
05/01	777 280	8.0	116	57	13	6282
/02	609 280	8.0	88	66	13	6491
/03	496 070	7.5	105	72	15	4724
/04	705 400	7.25	115	73	15	6346
/05	525 820	8.0	90	70	13	5477
/07	557 460	8.0	108	78	13	4839
/08	198 300	4.0	79	43	13	4706
/09	380 340	7.5	86	37	13	4423
/10	355 500	8.0	61	41	13	5464
Fall Lift						
10/15	807 990	7.5	148	70	15	5459
/16	853 660	8.0	153	73	15	5231
/22	831 900	7.5	136	68	15	6117
/23	776 470	7.5	149	65	15	5211
/24	935 510	8.25	124	62	15	6859
/26	872 690	8.0	134	69	15	6106
/27	297 910	3.0	133	62	15	5600
/29	589 960	6.25	117	61	15	6051
/30	798 140	8.0	104	71	15	7195
/31	549 220	7.0	112	-	15	5254

Source: Thunder Bay Forest Nursery

approximately 2 to 7 km/hr. Cloud cover at the three time trials was clear, partly cloudy and overcast, respectively. Some precipitation occurred during the second time trial.

Bulk Lift

During the spring bulk lift the mechanical harvester received limited use due to mechanical breakdowns. Only 13 percent of the intended lift of 130 000 seedlings was completed with the harvester. A total payable time of 12 hours was used in the cost analysis. The mechanical harvester was in operation for approximately 6 hours with an additional 6 hours lost to mechanical breakdowns.

Mechanical problems experienced during the spring bulk lift were a result of soil build-up on the belts and pulleys of the harvester. Modifications made to the harvester during the summer of 1990 proved effective and the fall bulk lift target of 180 000 seedlings was met. Some mechanical problems occurred but downtime was significantly less compared to the spring bulk lift.

Productivity

During the fall bulk lift approximately 177 648 seedlings were harvested over a period of 18.9 total hours with the mechanical seedling harvester. This equated to a productivity estimate of 9 400 seedlings per hour. Of the gross operating time, 5.2 hours were lost due to mechanical breakdowns and 1.95 hours were used for lunch and coffee breaks, resulting in a total of 11.75 hours net operating time. Based on net operating time, machine productivity was estimated at 15 200 seedlings per hour. A detailed outline of the harvester operating times and a description of mechanical breakdowns is given in Appendix IV.

The contractor had an average of 12 people working on the bulk lift. This included two machine operators, three tree handlers, three box handlers, one truck driver and a loader, one box marker and one supervisor. An additional 14 people were involved in assembling boxes, delivering boxes to the field and working at the loading dock for both the bulk and conventional lifts.

Twenty-two beds of seedlings were harvested with the mechanical harvester during the fall of 1990. The time required to harvest a bed (150 m in length) in compartment 58 averaged 21.5 minutes. The turn-around time averaged 5 minutes. An average of 37 boxes of seedlings were harvested per bed. Seedling counts per box indicated that boxes harvested from compartment 58 contained an average of 203.12 seedlings. Based on these figures approximately 16 800 seedlings were harvested per hour.

In compartment 48, which had a higher seedling density (Table 1), harvest time averaged 29.2 minutes per bed (150 m in length) with an average turn-around time of 4.5 minutes. The slower speed was partially offset by an increase in the average number of boxes of seedlings harvested (52 boxes versus 37 per bed for compartments 48 and 58, repectively). However, there were fewer seedlings per box from compartment 48, each box containing an average of 163.75 seedlings. This equates to a harvest rate of approximately 15 400 seedlings harvested per hour in this compartment.

During the spring bulk lift, the first bed in the nursery compartment (140 m in length) generated 35 full boxes of seedlings and was lifted in 24 minutes. There was an average of 174.65 seedlings per box. The turn-around time was approximately 4 minutes. A harvest rate was calculated at approximately 13 100 seedlings per hour.

Productivity was also measured as the number of full boxes being produced in a five minute period. Productivity in compartment 58 ranged from five to 14 full boxes and averaged 9.04 full boxes of seedlings being produced in a five minute interval. The estimated number of seedlings being harvested per person per 7.5 hour day ranged from 5 952 to 16 666 seedlings and averaged 10 761 seedlings.

In compartment 48, productivity ranged from five to 12 full boxes with an average of 8.92 full boxes of seedlings harvested in a five minute interval. This equates to a range of 5 352 to 12 846 seedlings with an average of 9 552 seedlings harvested per person per 7.5 hour day.

These results were similar to those obtained during the spring bulk lift. Productivity ranged from six to 10 full boxes with an average of 7.3 full boxes being produced in a five minute interval. The estimated number of seedlings being lifted per person per 7.5 hour day ranged from 6 736 to 17 465 seedlings with an average of 10 243 seedlings.

To determine if the maximum productivity had been reached or if there was still the potential of an increase in productivity, the number of seedlings harvested in a five minute period for the fall bulk lift were plotted over the interval number (Figures 9-11).

Bulk lifting productivity in compartment 58 during October 24 increased throughout the day (Figure 9) indicating that productivity had not reached a maximum. A similar pattern is shown in Figure 10 for compartment 58 on October 26. Figure 11 shows little change in bulk lifting productivity in compartment 48 on October 26. The slope of the line, being close to zero, is not statistically significant ($P<0.05$), indicating that the productivity limit for lifting seedlings in this compartment has been reached.

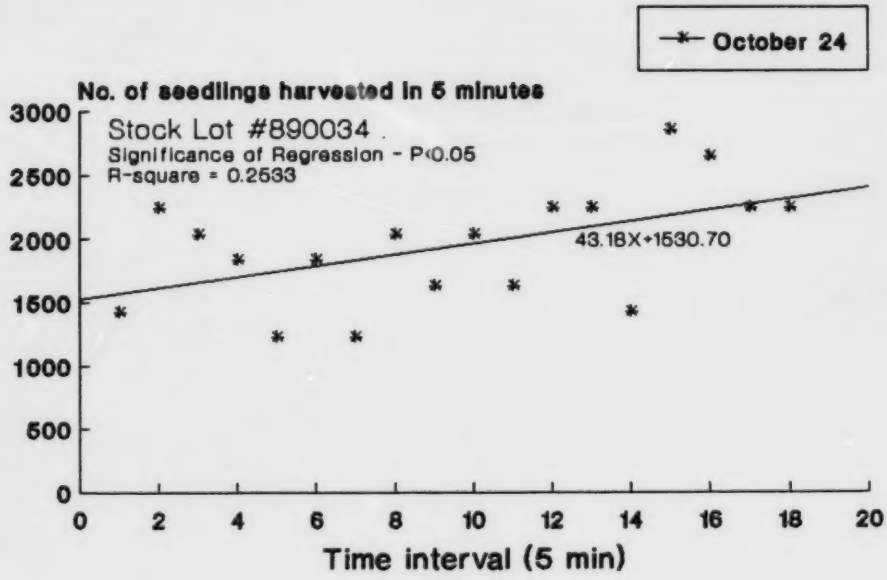

Figure 9. Change in productivity of the fall bulk lift based on the number of seedlings harvested in five minute intervals in compartment 58 on October 24, 1990.

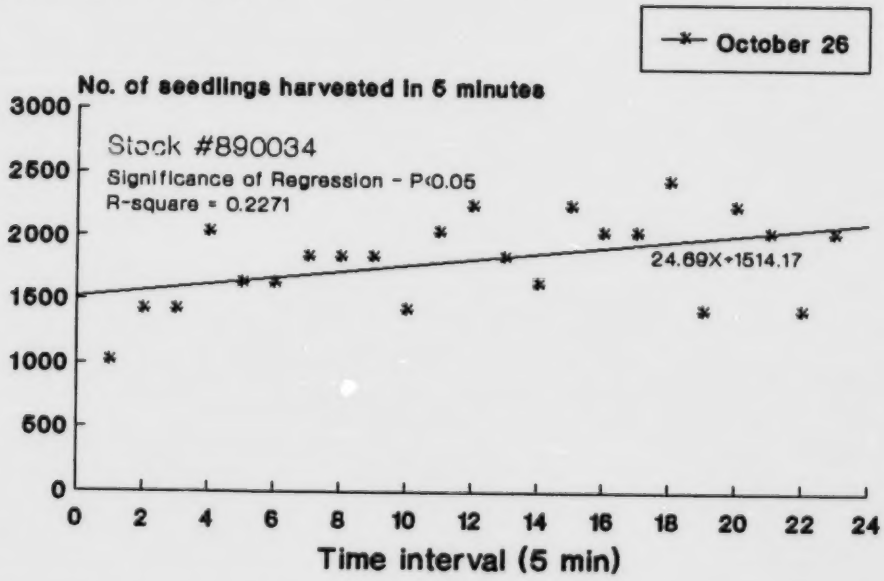

Figure 10. Change in productivity of the fall bulk lift based on the number of seedlings harvested in five minute intervals in compartment 58 on October 26, 1990.

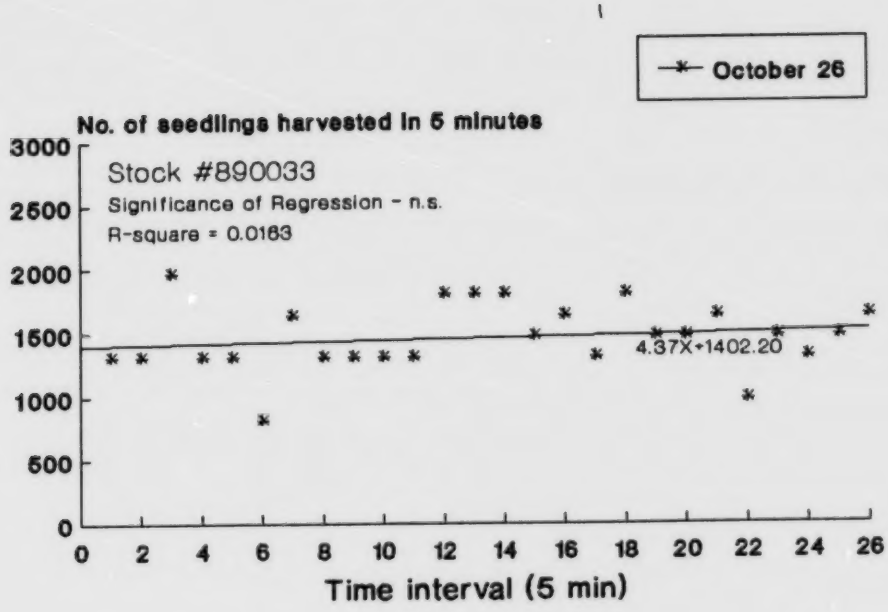

Figure 11. Change in productivity of the fall bulk lift based on the number of seedlings harvested in five minute intervals in compartment 48 on October 26, 1990.

Time Study

For the mechanical bulk harvest in the spring, the time elapsed between seedling removal from the ground to when the full box was placed in the cooler was 26 and 52 minutes for time trials one and two, respectively. The average was 39 minutes. Seedlings loaded onto the truck near the beginning of a load would sit on the back of the truck longer than those that were loaded near the end of a load. Root exposure times were very short in both trials. In the first trial, the box was closed two minutes after the seedlings in it were removed from the ground. In the second trial the box was closed 42 seconds after the seedlings in it were removed from the ground.

The temperature during the mechanical bulk lift was slightly above freezing. It was windy with winds out of the west at approximately 10-15 km/h. There was 100 percent cloud cover and some scattered snow flurries.

Timing studies on a limited basis were also done for the hand bulk lift during the spring lift. Time from undercutting until seedlings were placed in the cooler was 58 minutes. Time of seedling removal from the ground to when the full box was placed in the cooler averaged 48 minutes. Root exposure time in the first trial averaged five minutes.

Box Counts and Cull Assessments

Stock from the two fall-lifted compartments and the spring, hand and mechanically bulk lifted seedlings were counted and assessed for cull separately (Table 3). Boxes of seedlings from compartment 58 had significantly more seedlings per box than the boxes of seedlings from compartment 48 ($P<0.001$). However, the number of seedlings per box from compartment 58 was also more variable. The number of seedlings per box for both bulk lifted compartments was less than the number per box for the conventional lift. Boxes of bundled seedlings from compartment 48 contained either 250 or 300 seedlings per box.

For the spring bulk lifted stock there were significantly fewer seedlings per box for the hand bulk lifted stock than for the mechanically bulk lifted stock ($P<0.01$). The variability in the number of seedlings per box was not significantly different between the two methods of bulk lifting.

Table 3. Number of seedlings per box and cull rates for the 1990 spring and fall bulk lifted stock at the Thunder Bay Forest Nursery.

	Number of Boxes	Number of seedlings/box		Cull Level/box	
		Mean	Range	Mean	Range
Fall lift					
Mechanically Bulk Lifted					
Compartment 58	25	203[a**]	130-302	8.44%	3-23%
Compartment 48	8	164[b]	151-190	8.17%	2-13%
Spring lift					
Mechanically Bulk Lifted	20	175[a***]	119-244	13.46%	6-23%
Hand Bulk Lifted	20	144[b]	90-190	9.64%	4-19%

* - numbers followed by different letters are significantly different at the 0.001 level of probability.
** - numbers followed by different letters are significantly different at the 0.01 level of probability.

Average cull levels were similar for the two compartments bulk lifted in the fall (Table 3). Less than 33 percent of the culled seedlings for both compartments were culled because of physical abnormalities or damage attributable to the mechanical harvester. Mechanical damage, mostly broken leaders, accounted for almost 20 percent of the culled seedlings for both compartments. The majority of the seedlings were culled because of growth deformities and inadequate size. Deformed root systems accounted for more than 50 percent of the cull seedlings. A complete list of the types of damage and the percent frequency for the fall lift is given in Appendix V.

Cull levels were higher for the mechanically bulk lifted stock than for the hand bulk lifted stock (Table 3). Mechanically bulk lifted trees had a higher incidence of seedlings with physical abnormalities and damage; 67 percent compared to 54 percent for the hand bulk lifted stock. Mechanical damage, mostly broken leaders, accounted for 37.23 percent of the culled seedlings for the mechanically bulk lifted stock versus 24.46 percent for the hand bulk lifted stock. Hand bulk lifted stock had a higher percent of misformed seedlings. Levels of cull for the two bulk lifting methods were similar for the other cull factors (Appendix VI).

During the spring lift, the conventionally lifted stock was also assessed for cull seedlings that made it through the sorting process in the field. The methodology used for this assessment is outlined in Day et al. (1985). For the ten bundles of conventionally lifted seedlings, cull levels were assessed at four percent. Three percent of this was a result of mechanical damage and one percent was due to seedling root area index (RAI) being below the acceptable standard.

Boxes of bulk lifted stock were heavier and contained more soil than boxes of conventionally harvested seedlings. Boxes of seedlings from compartment 58 and 48 averaged 27 and 36 kg, respectively. In contrast, boxes of bundled seedlings (i.e. conventional lift) from a similar compartment weighed only 19 kg. This difference was statistically significant at a probability level of less than 0.1 percent ($P<0.001$). Soil in the boxes from compartment 58 weighed 12 kg (42 percent of the total box weight) compared to 23 kg (64 percent of the total box weight) from compartment 48. Soil in boxes of bundled seedlings was not weighed but was observed to be relatively insignificant.

During the spring bulk lift, there was a greater degree of root separation and less root intertwining between seedlings in the mechanically bulk lifted stock than for the hand bulk lifted stock.

Nursery Assessment Plots

Bulk lifted seedlings with visible evidence of where they were gripped by the belts of the harvester were planted in the spring. A number of these seedlings were excavated in the fall of the same year and examined under a microscope to determine if there was any persistent damage to the cambium and/or bark tissue. Fourteen trees were examined. All seedlings continued to show some evidence of where they were gripped. In most cases the only visible evidence was that all of the needles were missing from a portion of the stem and branches in a 4 to 6 cm band.

Only two seedlings had any visible damage to the bark or cambium and one had a partially broken terminal leader. In the latter instance, a lateral branch had taken over for the broken terminal. On one of the damaged seedlings the bark was stripped from two sides. On the second seedling no damage to the bark on the main stem was evident but the inner tissue on two sides of the stem was missing. There were also small lesions on several side branches in the area gripped by the belts of the harvester. In addition, two branches from within the gripped area were dead.

Area Base Plant

Packing Time Data

Planters were timed as they packed their planting bags with trees at their tree cache. Tree caches were spread out along the access route with three to four planters working out of each cache. Four planters were timed as they packed bulk lifted stock. No distinction was made between hand bulk lifted and mechanically bulk lifted stock. Packing times for the bulk lifted stock ranged from eight minutes to 14 minutes with an average time of 10.7 minutes. Three planters were timed packing conventionally lifted stock (bundled seedlings). Packing times ranged from four minutes to nine minutes with an average of 6.3 minutes.

It was difficult to obtain accurate seedling packing times. Planters often took breaks in the middle of loading up and sometimes got help from the crew bosses. In addition, boxes of stock at the cache site were mixed with boxes of bundled stock and bulk lifted stock occurring at the same cache site. Planters would often finish with one box and grab the next closest box to fill their planting bags with seedlings. This may not have been the same type of stock as was packed first. This became more of a problem near the end of the bareroot portion of the plant.

Questionnaire Responses

Planters were asked a series of questions regarding their opinions of bulk lifted stock and area base planting. Six planters out of the 17-20 on site were interviewed. Most were novice planters. Details of the questions asked and their replies are in Appendix II.

DISCUSSION

Cost Model for Bulk Lift - Area Based Plant System

Bulk Lift Versus Conventional Lift

Productivity for the spring conventional lift was below the levels anticipated. The minimum number of trees per production day as stated in the contract was 700 000. This minimum was met on only four out of the 15 days that it took to complete the lift. Average daily production was approximately 553 500 seedlings per 7.5 hour day.

Productivity targets for the fall conventional lift were met on all but the last of the 10 day lift. Two working days were shortened due to unfavourable weather. Average daily production was approximately 772 300 seedlings per 7.5 hour day.

Costs to the Ministry of Natural Resources of the 1990 spring and fall conventional lifts are summarized in Table 4. These costs averaged $52.75/1 000 seedlings. Complete breakdowns of the estimated and actual costs for the 1990 spring and fall conventional seedling harvests are given in Appendix VII. Cost per thousand seedlings was similar for the spring and fall lifts. For the spring lift, total costs incurred by the contractor were estimated at $291,349. The contractor's estimated margin of profit based on the payment to the contractor was 25.5 percent (Appendix VII). For the fall lift, contractor costs were estimated at $227,688. The estimated profit margin based on the actual payment to the contractor was quite high at 46.8 percent (Appendix VII).

One of the drawbacks to bulk harvesting is that harvest estimates are only as accurate as nursery bed inventory estimates. In the 11.75 hours that the harvester was in operation in the fall, 931 boxes of seedlings were harvested. There were 640 boxes from compartment 58 and 291 boxes from compartment 48. Using

Table 4. Cost of the 1990 spring and fall conventional seedling harvests at the Thunder Bay Forest Nursery.

	Number of Days	Total Number of Seedlings	Payment to Contractor	MNR Direct Costs	Total Cost to MNR	Cost/ 1 000 seedlings
Spring Lift	15	8 156 119	$365,806	$65,676	$431,481	$52.91
Fall Lift	10	7 310 760	$334,312	$50,130	$384,442	$52.59

the average seedling counts of 203 and 164 seedlings per box for compartments 58 and 48, respectively, a total of approximately 177 648 seedlings were harvested. This differs from the nursery's estimate of the number of seedlings harvested. Based on their in-bed inventory, approximately 195 624 seedlings were harvested. Their estimate was used to determine the payment to the contractor.

For the spring bulk harvest, 75 boxes of seedlings were harvested with the mechanical harvester. Using the average of 174.65 seedlings per box this equated to 13 000 seedlings in 1.5 days or 9 000 seedlings per day. This was extremely low, but is a result of the considerable amount of downtime. For comparative purposes an estimate of potential harvester productivity was obtained based on seedlings harvested in several five minute intervals. An estimated daily production level of just below 96 000 seedlings per 7.5 hour day was obtained (7.3 boxes X 174.65 seedlings per box X (12 minus 2) five minute intervals per hour X 7.5 hours per day = 95 620.875 seedlings per day). This equates to 144 000 seedlings in 12 hours. The two, five minute intervals for the turn-around time of the harvester were subtracted from the number per hour.

Costs for the 1990 spring and fall bulk lifts are summarized in Table 5. For the fall bulk lift, the contractor submitted separate bids for the mechanical

bulk lift and for the conventional lift. The bid price for the mechanical bulk lift was $24.45/1 000 seedlings and was used to determine the actual payment to the contractor. In addition, an estimated payment to the contractor is included in the table and was based on an estimate of the contractor's costs plus an assumed profit margin of 30 percent. To obtain this cost estimate, two additional assumptions had to be made. The first was that the mechanical harvest was a separate operation and that there would be no crossover of employees or equipment to the manual lift should a mechanical breakdown occur. And the second was that there were 17.4 hours of productive time for which employees had to be paid. Equipment rates were calculated as per the methodology for the conventional lift.

Table 5. Summary of costs for the 1990 spring and fall bulk lifts.

	Number of hours	Total Number of Seedlings	Payment to Contractor	MNR Direct Costs	Total Cost to MNR	Cost/ 1 000 Seedlings
Fall Lift						
actual	17.4	177 648	$4,586[2]	$2,025[4]	$6,611	$37.21
estimate	17.4	177 648	$5,631[3]	$2,025[4]	$7,656	$43.10
Spring Lift						
actual	12	13 000	$4,000[3]	$1,402[4]	$5,402	$415.55
estimate	12	144 000[1]	$4,000[3]	$2,318[4]	$6,318	$43.88

[1] estimate of potential machine productivity based on the number of seedlings harvested in several five minute intervals.
[2] actual payment to contractor by MNR. Includes payment for trees harvested plus early completion bonus minus rental charges and liquidated damages.
[3] payment based on estimate of contractor's costs for each lift plus a profit margin of 30 percent.
[4] part actual (supplies - boxes, liners and staples) and part estimate (root pruning, undercutting, MNR salaries and equipment).

For the spring bulk lift, the contractor submitted only one bid price. No distinction was made between the bulk and the conventional lift and therefore the actual payment to the contractor for the bulk lift could not be determined. For cost analysis, payment to the contractor for the spring bulk lift was determined by using an estimate of the contractor's costs plus an assumed profit margin of 30 percent. The two assumptions noted for the fall bulk lift were also used except that productive time for which employees had to be paid was 12 hours. A complete cost breakdown for both the spring and fall bulk lifts are given in Appendix VIII. These costs do not include capital costs associated with purchasing the mechanical belt seedling harvester.

Based on the productivity figures for the fall bulk lift, approximately seven mechanical harvesters would be required to harvest an equal number of seedlings as were lifted in the fall conventional lift in the same time period. This assumes no major downtime due to mechanical or other problems. An additional four tractors with a belly blade attachment would also be required. Approximately 84 workers would be required to staff the harvesters and tractors. This is less than half the number of staff required for the conventional seedling harvest.

Total cost to the MNR for the fall bulk harvest, based on the actual payment to the contractor, was approximately $37.21/1 000 seedlings (Table 5), compared to a cost of $52.59/1 000 seedlings (Table 4) for the fall conventional lift. This equates to a cost savings of $15.38/1 000 seedlings or 29 percent from the cost of the conventional seedling harvest. This is similar to results obtained at the Swastika Forest Nursery. An estimated cost savings of $15.00/ 1 000 seedlings was realized for seedlings harvested at the Swastika Forest Nursery using the mechanical belt seedling harvester (Wayne Nakamura, pers. comm. 1990).

Cost of the fall bulk harvest based on the estimated contractor's costs for manpower, supplies and equipment plus an assumed profit margin of 30 percent is slightly higher at $43.10/1 000 seedlings (Table 5). The cost savings when compared to the conventional lift were lower (but still substantial) at $9.49/1 000 seedlings or 18 percent.

The cost of lifting seedlings using the mechanical harvester is dependent on machine productivity. Factors affecting productivity will therefore have a direct influence on the cost of the lifting operation. One of these factors is seedling density in the nursery beds. Seedling density may vary by stock type and method of transplanting. Higher seedling densities may result in higher productivity which may, in turn, result in lower costs.

The effect of seedling density on the cost of bulk harvesting was observed during the fall bulk lift. Two compartments having different densities (Table 1) were harvested using the mechanical harvester. The difference in seedling density between the two compartments was 13 seedlings per lineal metre or approximately 25 percent. A cost analysis was done treating the stock from the two compartments separately (Appendix IX), and assuming no mechanical breakdowns. The cost of harvesting compartment 58 was $32.25/1 000 seedlings while the cost of harvesting compartment 48 was $30.74/1 000 seedlings. The difference in cost was $1.51/1 000 seedlings or almost five percent. The effect of varying seedling density on machine productivity requires further investigation under controlled conditions. The effect of spacing on seedling quality should not be overlooked when the potential cost savings of more dense nursery beds are examined.

Another factor that affected productivity was the time of day (Figures 9 and 10). In compartment 58, crew productivity increased significantly during the day. This increase may be a result of the lifting crew becoming more experienced

with the harvester. The line denoting productivity (Figures 9 and 10) had not yet begun to level off indicating that the maximum productivity for that compartment had not been reached. In compartment 48 there was a slight but not statistically significant increase in crew productivity (Figure 11). This indicates that maximum productivity had been reached in this compartment. Further productivity data is required before any definitive conclusions can be made regarding maximum productivity levels for the mechanical bulk seedling harvester.

Shipping Costs for Bulk Lift Versus Conventional Lift

Differences in the cost of shipping seedlings to the field for the two methods of lifting depends upon the number of seedlings per box. Fewer seedlings per box increases shipping costs as more trailers would be required to get the same number of seedlings to the planting site. Boxes of fall bulk lifted stock from both compartments contained, on average, fewer seedlings than boxes of conventionally lifted stock from the same compartment.

Boxes of bulk lifted stock from compartment 58 contained an average of 203 seedlings per box while boxes from compartment 48 contained an average of 164 seedlings per box. This compares to 250 or 300 seedlings per box for the conventionally lifted stock. Fewer seedlings per box of bulk lifted stock was partly due to excessive soil in the boxes, leaving less room in the box for seedlings. Based on these data, it could be expected that shipping mechanically bulk lifted stock may cost between approximately 52 and 83 percent more than shipping conventionally lifted stock. However, the validity of this assumption requires further investigation.

Excessive soil in the boxes of bulk lifted stock also resulted in these boxes weighing significantly more than the boxes of conventionally lifted stock ($P<0.001$). Heavier box weights could result in further problems with shipping seedlings to the planting site and increased shipping costs. Fewer trees could be shipped per load if weight restrictions for travel on highways and/or logging roads were in effect. Increased box weights could result in a higher incidence of box crushing resulting in seedling damage. They could also result in an increased incidence of work related injuries, especially back injuries.

Area Base Versus Conventional Tree Planting

This project was not a true area base plant as the planters in this project were paid by the tree. As a result, it was not possible to obtain specific cost figures. The Nipigon project had the highest payment to the contractor at $276.00/1 000 seedlings (B. James[5], pers. comm. 1990). This compares to an average payment of $198.00/1 000 seedlings for all other tree planting contracts in the North Central Region in 1990. The contractor hired to do the job did not have the lowest bid. Two other contractors had lower bids but turned down the contract due to other commitments.

Other Ontario area base plants were conducted in Wawa and North Bay in 1990. In Wawa, planters were paid on an hourly basis while in North Bay, planters were paid by the area planted. Cost figures from Wawa show a bid price of $318.64/ha for planting 60 000 seedlings on 37.3 ha (Barns 1990). This resulted in a payment to the contractor of $198.09/1 000 seedlings, similar to the average cost for conventional tree planting projects in the North Central Region.

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[5] Regional Forest Operations Manager, North Central Region, Ontario Ministry of Natural Resources.

In North Bay, three areas were contracted out as area base plants (194 ha). Bid prices averaged $433.58/ha (range $393.55 - $460.44/ha). Different bid prices were a result of differing degrees of difficulty in the areas to be planted. Costs per 1 000 seedlings were $245.36, $235.13, and $336.57, respectively.

Area base planting is more expensive than per tree planting on a per thousand seedling basis. However, on a per hectare basis the opposite is true. This is because fewer trees are planted per hectare with area base planting than with per tree planting. As a comparison, in Thunder Bay district in 1989, a total of 1 698 200 bareroot and container seedlings were planted on 713.6 ha at a cost of $369,600. This equates to a cost of $517.94/ha or $217.64/1000. This compares to a cost of $483.73/ha or $283.98/1 000 seedlings for the 1989 Nipigon area base plant (Hardy and Zitnak 1989) and $552.18/ha or $418.08/1 000 seedlings for the 1989 area base plant conducted in North Bay district (Beaton et al. 1989). One of the sites in the North Bay area base plant could only be accessed by boat resulting in unusually high costs. Details of the 1989 and 1990 costs for conventional per-tree and area base planting projects are included in Appendix X.

Initial high bids for area base planting projects should not deter the province from continuing to use this system of payment. These high bid prices reflect the uncertainty and unfamiliarity of eastern Canadian contractors with area base planting. It can be expected that bid prices will decrease as contractors become more familiar with area base planting (C. Von Hahn[6], pers. comm. 1990). In the first year after area base planting was introduced in British

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[6] Planting Program Specialist, British Columbia Ministry of Forests.

Columbia, bid prices were extremely high but showed a marked reduction in the second year as contractors gained experience with area base planting.

Increased costs of area base planting may be offset by cost savings resulting from a reduction in the number of seedlings required. For the three 1989 area base planting projects in Ontario, there was a surplus of 81 646 seedlings or 14.45 percent of the total seedlings planted (Brinkman 1989). Based on a cost of $0.12/seedling this equates to a cost savings of $9,797.52 or $28.99/ha on the three projects.

Seedling Lift

Conventional versus Bulk Lift

Bulk lifting with a mechanical belt harvester requires substantially less manual labour compared to conventional lifting. This reduces the cost of lifting seedlings at the nursery providing that harvester productivity can be maintained at a satisfactory level. In addition, the amount of time seedling roots are exposed to air is reduced, and less handling of the seedlings lowers the potential risk of seedling damage (Trewin 1976).

Bulk lifting with a mechanical belt harvester also has several disadvantages. The gripping action of the belts may damage seedlings as they are being removed from the ground. If the belts grip seedlings too tightly, the cambium may be crushed. If the belts do not grip the seedlings tightly enough, the belts may slide up the seedling removing needles and small branches from the stem and damage the tree. Seedlings may also be damaged by the oscillating metal frame that removes soil from the roots. Broken terminal shoots caused by the frame action were a common problem.

Although one of the advantages of bulk lifting is that the sorting and culling stage and its associated cost has been removed from the lift operation, a potential disadvantage also exists. Since the seedlings are no longer sorted and culled, there is a potential increase in the number of cull seedlings that may be shipped to the field and planted. The severity of this problem depends upon, 1) field cull levels at the nursery, which vary with stock lot and cultural practices, 2) on the training received by planters in identifying cull seedlings, and 3) on a planter's willingness to discard substandard seedlings.

An exact count of the number of seedlings in a box cannot be done under the bulk lift method. This has led to difficulties when the bulk lifted seedlings are sent to be planted. Variable numbers of seedlings per box will not be a problem if the bulk lifted stock is used in conjunction with an area base plant.

A lack of area base planting projects has resulted in limited demand for bulk lifted stock. Bulk lifted stock does not integrate well with the per tree payment system because of the variable number of seedlings per box and an increase in the number of cull seedlings being shipped. The lack of area base planting projects is partially a result of contractual procedures but also results from a lack of;

1) suitable sites,
2) suitable site preparation,
3) funds, and
4) knowledge about area base planting on the part of MNR and the contractors (D. Jackson[7], pers. comm. 1991).

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[7] Forest Management Services Officer, Nipigon District, Ontario Ministry of Natural Resources.

Time Study

Root exposure times for both the mechanical and hand bulk lifts were considerably less than for the conventional lift. Decreased root exposure times result in less root desiccation and may ultimately lead to better seedling survival after outplanting in the field.

Box Counts and Cull Assessments

Variable seedling counts can cause problems with shipping inventory, especially if the bulk lifted stock is sent to more than one site. There is a possibility of seedling shortages or conversely, a surplus of stock.

The bulk lift and area base plant systems compliment each other. If planters are being paid on an area basis then the variable numbers of seedlings per box is only a minor concern as the planters and supervisors are more interested in the area that is planted to the required seedling density. Variability in the number of seedlings per box will only be a major problem if planters are being paid on a per tree basis.

Average cull levels were similar (eight percent) for the two compartments bulk lifted in the fall. This is the same as the nursery's expected cull levels obtained from their pre-harvest stock inventory for these compartments. Only a small percentage of seedlings were culled because of damage caused by the harvester. Mechanical damage generally resulted in broken terminal leaders or lateral branches.

Seedling breakage likely results from the action of the metal bars that clean soil from the roots. The amount of breakage seems to be affected by the height above the ground at which the belt grips the seedling. The higher the seedling is gripped, the greater the risk of breakage.

The amount of breakage also seems to be affected by the temperature during the lift. Under usual circumstances, seedlings are fairly pliable and can withstand the bending action caused by the metal cleaning bars. However, in cool weather, seedlings tend to be more brittle and therefore can be more easily broken.

The majority of the cull seedlings were misformed as a result of cultural practices and not the method of harvest. It should be noted that the bulk harvesting trial was conducted in transplant beds that were not tended or cultured to specifically accommodate this method of harvesting. If bulk harvesting became operational on a large scale, small or misformed trees could easily be removed during hand weeding operations in the nursery beds.

The effect of excessive soil in boxes of bulk lifted stock and increased box weights on shipping costs has been discussed previously. In addition, loss of soil from the nursery may also be a problem. Soil in the boxes is mostly topsoil and contains the majority of nutrients added through soil amendments. An average of 12 and 23 kg of soil per box was contained in boxes of seedlings from compartment 58 and 48, respectively. Based on the number of boxes shipped, this equates to a total of approximately 14 tonnes of soil shipped off of the nursery from the fall bulk lift. If 8 million seedlings were shipped, the semi-annual loss of nursery soil would exceed 490 tonnes.

Boxes of seedlings lifted from compartment 48 contained almost twice as much soil as boxes of seedlings lifted from compartment 58. This may be attributable to the density of seedlings in the nursery beds and the resultant effect on soil moisture conditions. There were approximately 25 percent more seedlings per lineal metre in compartment 48 than in compartment 58. Increased shading in some nursery beds results in cooler soil surface temperatures and less

evaporation from the soil surface, allowing the soil to retain more moisture. The effect of this is twofold. First, moist soil weighs more than an equal volume of dry soil. Second, moist soil is more difficult to separate from the roots of seedlings and thus more soil ends up in the boxes. Improvements to the shaker system on the belt harvester are planned to alleviate this problem.

Potential damage to seedlings caused by the belts of the mechanical harvester crushing the cambium was assessed after the seedlings had been grown in the field for one season. All assessed seedlings continued to show some evidence of where they had been gripped by the belts of the harvester. In most cases, the only visible evidence was that all of the needles from the stem and branches in a 4-6 cm band were missing. Two seedlings showed evidence of damage to the bark and cambium and one had a broken leader. However, this damage did not seem to have an adverse effect on the seedlings as they were otherwise healthy. The long term effects of the potential damage requires further investigation.

Area Base Plant

Results obtained from the area base planting portion of this project must be viewed with caution. Planters were paid by the tree rather than by the area planted, negating any potential benefits of area base planting. The per tree payment system created problems with the use of bulk lifted stock since the numbers of seedlings per box is variable. This may have influenced the results of the questionnaire and the planter's packing times.

Packing Times

The lifting system used at the nursery appeared to have only a minor effect on the time required for the planters to pack their planting bags with seedlings. On average, packing times with bulk lifted stock were only slightly longer than packing times for bundled stock. The major reason for the increased packing time was that the planters had to try to untangle the roots of the bulk lifted stock and had to sort the seedlings to remove any culls. Had the increase in packing times for bulk lifted stock been significant, this may have resulted in lower tree planter productivity.

Questionnaire Responses

Planter responses to the questionnaire were somewhat variable among the largely inexperienced planters. Half of the planters questioned felt bulk lifted stock was more difficult to handle than bundled stock while the other half felt that there was no real difference in handling difficulty between the two stock types. The reason given in the first instance was that seedlings were loose and difficult to organize. They also found that roots of the bulk lifted stock were more tangled and required greater effort to separate. Handling difficulties manifested themselves when planters were dipping the seedling roots and when seedlings were being packed into the planting bags. Half of the planters surveyed felt that it took them longer to pack their planting bags with bulk lifted stock than with bundled stock. However, packing time data did not indicate a significant difference in packing times for the two stock types. One planter felt that because the bulk lifted seedlings were loose, they may be more easily damaged when they were being put into the planting bag.

All planters were required to cull substandard seedlings based on culling criteria used in the nursery as agreed upon at the pre-plant start-up meeting. During a field visit, project staff found that planters were not culling seedlings nor had they been instructed to cull seedlings. An on-site meeting involving project staff, the MNR representative and the contractor resolved the situation. Problems of this nature are understandable and were due to a lack of familiarity by both parties with planting bulk lifted stock. Problems should be minimized as more experience with bulk lifted stock is gained and handling procedures are discussed during start-up meetings.

Most planters culled seedlings both at roadside as they packed their planting bags and in the field as they planted. Only two planters felt that culling seedlings made loading up more difficult. It might be expected that planters would tend to cull heavily because they were being paid by the average number of seedlings in a box regardless of the actual number of seedlings. However, this did not seem to be the case and no abuses of the culling rules were observed.

After planting for a few days with bulk lifted stock, planter opinion tended to become more negative with regard to this method of lifting. However this could have been avoided if the planters had been paid by the area as was the original intent of this project.

Problems Encountered with the Area Base Planting Project

The biggest problem encountered with the area base planting phase of this project was that the tree planters continued to be paid by the tree instead of by the area. This raises concerns about the validity of the data obtained from this phase of the project. A spokesman for the planting contractor gave several

reasons why the planters' payment continued to be on a per tree basis. The company felt that it would be too difficult to flag off the blocks into planting units because of inconsistencies in the planting area. There were many rocky spots, clumps of residual trees and no symmetrical shape to the cut. He also was not confident in his own or in his foremen's ability to flag out areas of known size or equal areas for each planter. There was also a concern that planters would miss plantable spots in order to cover as much area as possible. He stated that planters were already having problems meeting density requirements and that these problems would be compounded if planters were paid by the area. He also felt that planters would run out of area too quickly and that the foremen would be continually having to find new blocks for the planters to plant.

The contractor was neither fully aware of the benefits of area base planting nor prepared for the amount of pre-plant work required to prepare an area for area base planting. As a result, the contractor opted for the easier route of paying his planters by the tree after viewing the site. It is recommended that in the future, contractors be required to provide a description of operations to accompany the bid for area base planting projects.

To be successful, area base planting contractors must pay their planters by the area. Currently MNR's planting contracts do not allow the MNR to dictate how a contractor must pay his employees. However, the MNR must have some say in how tree planters are paid as this has a direct bearing on planting objectives which, in turn, are reflected in the contract objectives. The British Columbia Ministry of Forests is currently trying to work into area base planting projects how contractors pay their employees (C. Von Hahn, pers. comm. 1990). In Ontario, another option is to have contractors submit proposals for areas to be planted using the area base payment system. Contractors prepared to pay planters by the

area would rank higher than those paying planters by the tree or by the hour. These options should be evaluated and a solution found for future area base planting projects.

The site selected for this project was not conducive to area base planting. Area base planting can be applied to any site but according to Lehane (1988) benefits increase with the difficulty of the planting site. He adds that the most dramatic results occur on sites where planting spots are few or unevenly distributed or where natural regeneration or partial stocking exists. Guthrie (1990) lists the following sites that should be considered for area base planting:

1) fill-ins, i.e. replanting plantation failures,
2) areas partially stocked with naturals or residuals,
3) underplanting, i.e. areas harvested using the shelterwood system,
4) sites on which it may not be possible to determine the plantable area,
5) sites with low numbers of plantable spots,
6) planting sites with patches or areas which must be avoided,
7) areas where planters are able to exceed the desired density because of available planting spots, and
8) backlog areas where some natural and residual regeneration exists.

To avoid some of the initial mental blocks against area base planting, Brinkman (1989) recommended that areas in which planting spots are pre-defined should be avoided (eg. patch scarifiers). The site chosen for this project did not satisfy any of these criteria.

First, the Nipigon planting site chosen for this study was site prepared with a Bracke patch scarifier, creating pre-defined planting spots. Planting spots were well defined and easy to find and were well distributed over the planting area. The only difficulty encountered was residual patches of trees that covered parts of the area. Continuous row scarification is preferable to patch scarification for area base planting.

Second, there was very little acceptable natural regeneration on the site. Survival and performance plots indicated only about 75 acceptable naturals per hectare and this estimate may be high. This equates to approximately 5 percent of the average target density. It is recommended that future area base planting test project sites contain more natural regeneration. The Northwestern Ontario Forest Technology Development Unit (NWOFTDU) is currently undertaking a number of projects to identify sites in which the amount of natural regeneration could be predicted using the Northwestern Ontario Forest Ecosystem Classification system.

Density of planted seedlings on the site was always found to be below the target density. In the assessment procedure, missed plantable spots in a plot were added to the number of planted trees in a plot in order to re-determine the target density. Because of the methodology used, this resulted in the contractor continually trying to increase his planters' planting density. As a result, an extra 41 200 seedlings (9.8 percent) were required to plant the site (B. James, pers. comm. 1990).

Limitations of the Study

Data collected for the fall 1990 mechanical bulk lift were sufficient to do an accurate cost analysis. However, there was still a relatively high percentage (29.9 percent) of downtime due to mechanical problems. A reduction in downtime should increase productivity, which, in turn, will reduce costs per 1 000 seedlings lifted. Opportunities for further studies with the mechanical bulk lifter may be limited because of the lack of demand for bulk lifted stock.

Results of the area base plant portion of this study must be viewed with caution because the contractor decided to pay his planters by the tree rather

than by the area. Similarly, planter opinion on bulk lifted stock may have also been influenced by the per tree method of payment. Planters were paid based on the average number of seedlings per box. The actual number of seedlings per box was extremely variable and hence the accuracy of the payment received for the number of trees actually planted is questionable. This may have resulted in the planters having a negative attitude toward the use of bulk lifted stock.

CONCLUSIONS

Based on the analysis of the variable costs of the 1990 mechanical bulk lift, it was concluded that the mechanical bulk lift was a cost effective alternative to conventional lifting. The mechanical bulk lift cost $15.38/1 000 seedling less than the conventional seedling lift even with the nearly 30 percent downtime due to mechanical problems. This equated to a potential cost savings of approximately $119,000 in the first year if the Thunder Bay Forest Nursery had been able to harvest 50 percent of the stock lifted in 1990 using mechanical bulk harvesters. Further testing is required to determine productivity levels that can be attained with the harvester without losses due to mechanical problems. Estimates of productivity, excluding downtime, indicated that approximately seven mechanical harvesters would be required to harvest the same number of seedlings as were lifted conventionally in the same time period. Fixed costs, i.e. purchase of the mechanical belt seedling harvester, were not figured into these cost calculations but must be kept in mind when evaluating the economic efficiency of the operation. Demand for bulk lifted stock must also be taken into account when determining whether to bulk harvest stock. Improvements to the belt harvester's shaker system are required to help alleviate the problem of excessive soil in boxes of bulk lifted stock.

Although area base planting is a viable alternative for regenerating certain sites in Ontario, it is not recommended for all sites and conditions. Area base planting should be restricted to sites most conducive to its use to overcome some of the initial mental blocks against it. Further study is required to obtain specific cost data.

Initial observations indicate that bulk lifting and area base planting are operationally compatible.

RECOMMENDATIONS

1. Continue to test the mechanical belt seedling harvester to more accurately determine obtainable productivity levels.

2. Increase the use of the area base payment system for contracting out tree planting to increase contractor familiarity with area base planting.

3. Organize a series of workshops for contractors and MNR staff to describe area base planting and outline how to conduct an area base plant. Assessment procedures, preparations and the advantages of bulk lifted stock should be emphasized.

4. Develop a contract for area base planting that ensures contractors pay tree planters by the area planted rather than by the number of trees planted or by the hour.

5. Select sites more appropriate to area base planting. See Guthrie (1990) for a list of sites most suited for area base planting.

6. Develop a provincial strategy to adopt a combined bulk lift - area base planting program as a portion of the annual nursery production, with a view to expanding the program with savings accrued from lower production and lifting costs.

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APPENDIX I

Nursery Grading and Culling Rules

(from Schedule A of the Seedling Lifting Contract)

Grading:

(1) Trees conforming to the following minimum size standards are acceptable for further processing:

(a) Ship stock size grading standards:

Species	Age	Minimum Height (cm)	Minimum RCD (mm)
Sb	All age classes	15	2.6
Sw	2+2	15	3.0
Pj	2+0	13	2.6
Pw	2+2	15	3.0

(2) All trees having any of the following defects are culls, are not acceptable for further processing and shall be left on top of the bed from which they were lifted or discarded.

(a) Growth deformities such as:

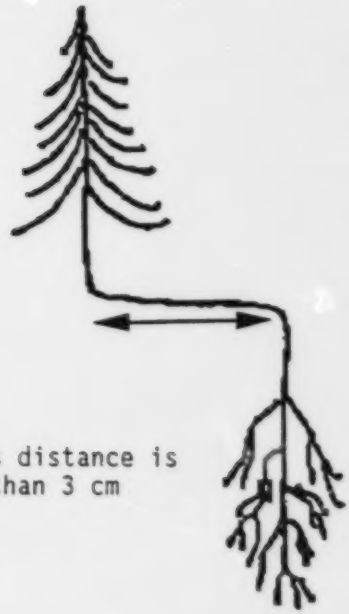
(i) non-acceptable root systems (see Figure 1)
(ii) misformed trees;

(b) Physical abnormalities or damage:

(i) badly stripped or broken roots;
(ii) root splits extending one-half of the distance or more through or around the stem;
(iii) too few fibrous roots to support the tree;
(iv) mechanical damage to the tree;
(v) badly discoloured needles;
(vi) fungi-moulded foliage or roots/disease/insects.

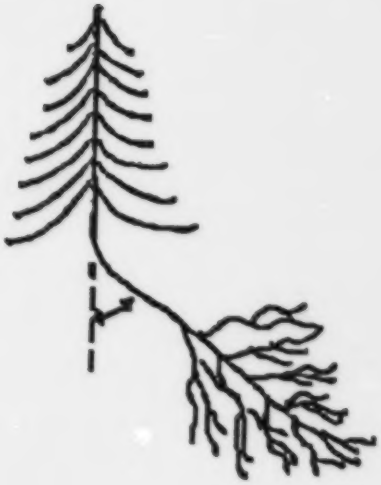
(3) In the course of grading, trees shall be separated one from the other.

NON-ACCEPTABLE ROOT SYSTEMS

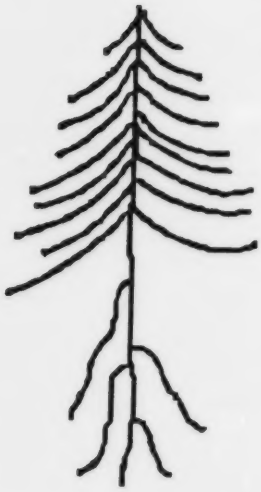


if this distance is more than 3 cm

this is a severe hockey stick



if this angle is greater than 45°



not enough root system to support the tree

APPENDIX II

Questions Asked to Tree Planters

and Their Responses

Questions Asked to Tree Planters and Their Responses

A total of 6 planters were interviewed. One had planted before while the others were all first time planters.

I Root Soaking

1) Are you soaking the roots?

Yes - 6; No - 0

They are actually dipping the roots of the trees in a puddle before they are putting them in their planting bags.

2) Is bulk stock harder to soak than bundled stock?

Yes - 3; Same - 1; No - 2

Loose - difficult to handle as trees go all over the place; bigger and not as organized.

II Loading up

1) How long does it take to load up with bulk stock?

2) Does it take longer to load up than with bundled stock? Why?

Yes - 3; Same - 3; No - 0;

1) Loose - therefore a pain to organize which takes longer.
2) A little longer 3 minutes more.
3) Same time span because there are no elastics to deal with.
4) Same
5) Harder to get a hold of the trees and harder to put into the bags. The way they are packed also makes it harder. Trees may also be more easily damaged when they are being put into the bag since they are loose.
6) Same

3) Is there a way of shortening loading time?

1) Stay with bundled or use container stock as you can carry a lot more. With bulk stock can only carry 100-150 because they're tangled and clumped together and loose. When pulling trees out they get all tangled (roots) and you have to take time to untangle them in the field. They also get tangled when you put them in the bag.
2) If they were bundled.
3) No
4) No
5) Don't count the trees.
6) If they were bundled.

III Culling

1) Are you culling trees as you load up with bulk stock?

Yes - 6; No - 0;

2) Who taught you what trees to cull? Were you shown or told?

Supervisor - 4 told; 2 told and shown.

3) Does culling make loading up more difficult?

Yes - 2; No - 4;

4) What kind of trees are you culling?

i) size only
5 planters.
ii) root systems - J-root
1 planter.
iii) physical damage - mold
5 planters.

5) Do you think you are a) planting cullable trees or b) culling plantable trees?

a) Yes - 0; No - 6
b) Yes - 0; No - 4; not sure - 1; 1 planter felt some questionable trees were being culled.

6) Do you cull at roadside or in the field?

Roadside - 1; Field - 1; both - 4;

7) Could improvements be made in this process?

None could be thought of.

IV Planting

1) Are you keeping track of the number of trees you are planting?

Yes - 0; No - 6;

2) Are you counting the number per box or as you plant? Or do you just consider it as 154? (the average #per box)

Yes - 0; No - 6 using average;

One planter had planted before, for the others this was there first season. We asked the one experienced planter what he thought of area base planting. He said he would rather stay with working on a per tree basis as he feels he can get paid more with the piecework system.

APPENDIX III

Schedule 'A' From the Nipigon Area Base

Planting Project Contract

SCHEDULE 'A'

to the Agreement between the Crown
in right of Ontario and

TENDER # NCR -89-018

PLANTING PRESCRIPTION

REGION: NORTH CENTRAL

DISTRICT: NIPIGON JOB #: 3 TWP/BM: 502873

SPECIES	NO. OF TREES	TYPE	AGE
Jack Pine	200,000	Container	0-W
White Spruce	90,000	Bareroot	2+2
Black Spruce	130,000	Bareroot	2+1 1/2
TOTAL	420,000		

ANTICIPATED DATE OF STOCK AVAILABILITY: May 14, 1990

LATEST COMPLETION DATE: June 15, 1990

SITE DESCRIPTION: Auden M.U.

AREA: Treated - 266.1 ha; Untreated - 17.8 ha, Total approx. 283.9 ha

PLANTABLE AREA: Same

TYPE OF SITE PREPARATION: Mechanical - Bracke

METHOD OF SITE PREPARATION: Spiral - Scalp

DATE OF SITE PREPARATION: August/September, 1989

DESIRED DENSITY: Varies as per Schedule "A"

SOIL DEPTH: Shallow to Deep

SOIL TEXTURE: Varies - Sand - Clay

STONINESS: None to significant

MOISTURE REGIME: Dry to wet

MINERAL SOIL EXPOSURE: N/A

ACCESS: Poor - see comments

SLASH CONDITIONS: Light to heavy

COMPETING VEGETATION: Poplar, Maple, Alder, White Birch, Cherry

ACCEPTABLE NATURAL REGENERATION: Black Spruce, White Spruce, Jack Pine

SPECIAL PLANTING PRESCRIPTION: Min. 1.8 m X 1.8 m spacing

1. Row Planting: Trees to be planted on upper slopes of bracke patches.
2. Other: Some scalping may be required in locations to achieve desired spacing and root placement in mineral soil.

LOCATIONS OF DELIVERY POINTS: South Girvan Loop Rd.

DISTANCE TO GOODS AND SERVICES: 2 Hours (Jellicoe, Ontario)

COMMENTS:

1. Payment by area.
2. Vehicles required for access: 4x4 1/2 ton, ATC's, tracked type vehicle (J5 or better and tracked trailer to move staff and trees on site.
3. Planting Shovel - minimum size to use approx. 8" x 7" deep.
4. Contractor movement (Block to Block) at District discretion.
5. Spruce trees to be planted using the "L" method.
6. Un-siteprepared blocks require the preparation of a suitable microsite (scalping).
7. Black Spruce stock is very large, approx. 100 trees/box
8. Bareroot stock will be bulk lifted. When stock is bulk lifted, an exact count of the number of trees by box is not available.

SCHEDULE "A" (continued)

PLANTING SUMMARY

1. In this Schedule "A":

(1) Column (1) refers to each part of the planting area, listed in order of sequence, as shown on the maps attached hereto that form part of this Schedule "A"; and

(2) Column (2) refers to the target dates which are the latest allowable commencement dates and latest allowable completion date for planting all the trees as referred to in column (2) attached hereto; and

(3) Column (3) refers to:

i) The nursery stock species to be planted in the part of the planting area referred to in column (1) attached hereto:

ii) the type meaning a nursery stock classification employed by the Crown;

iii) age meaning a designated classification employed by the Crown such as 2+2 for bareroot stock; or O/W and current for container stock; and

(4) Column (4) refers to the objective spacing between nursery stock to be used in the part of the planting area referred to in column (1) attached hereto; and

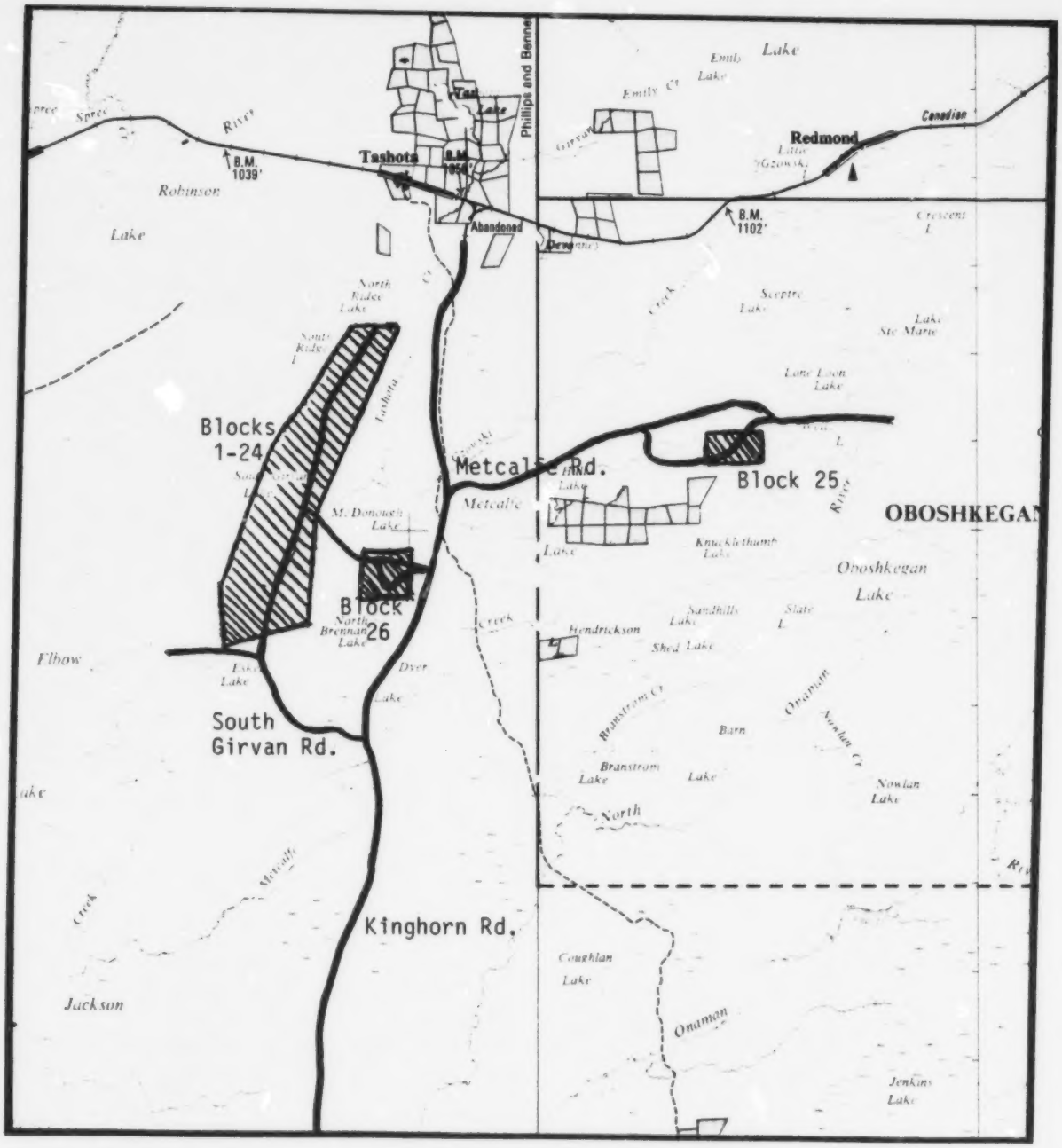
(5) Column (5) refers to the estimated average target density in trees/ha across the total area referred to in column (1) attached hereto; and

(6) Column (6) refers to the total area for that part of the planting area referred to in column (1) attached hereto; and

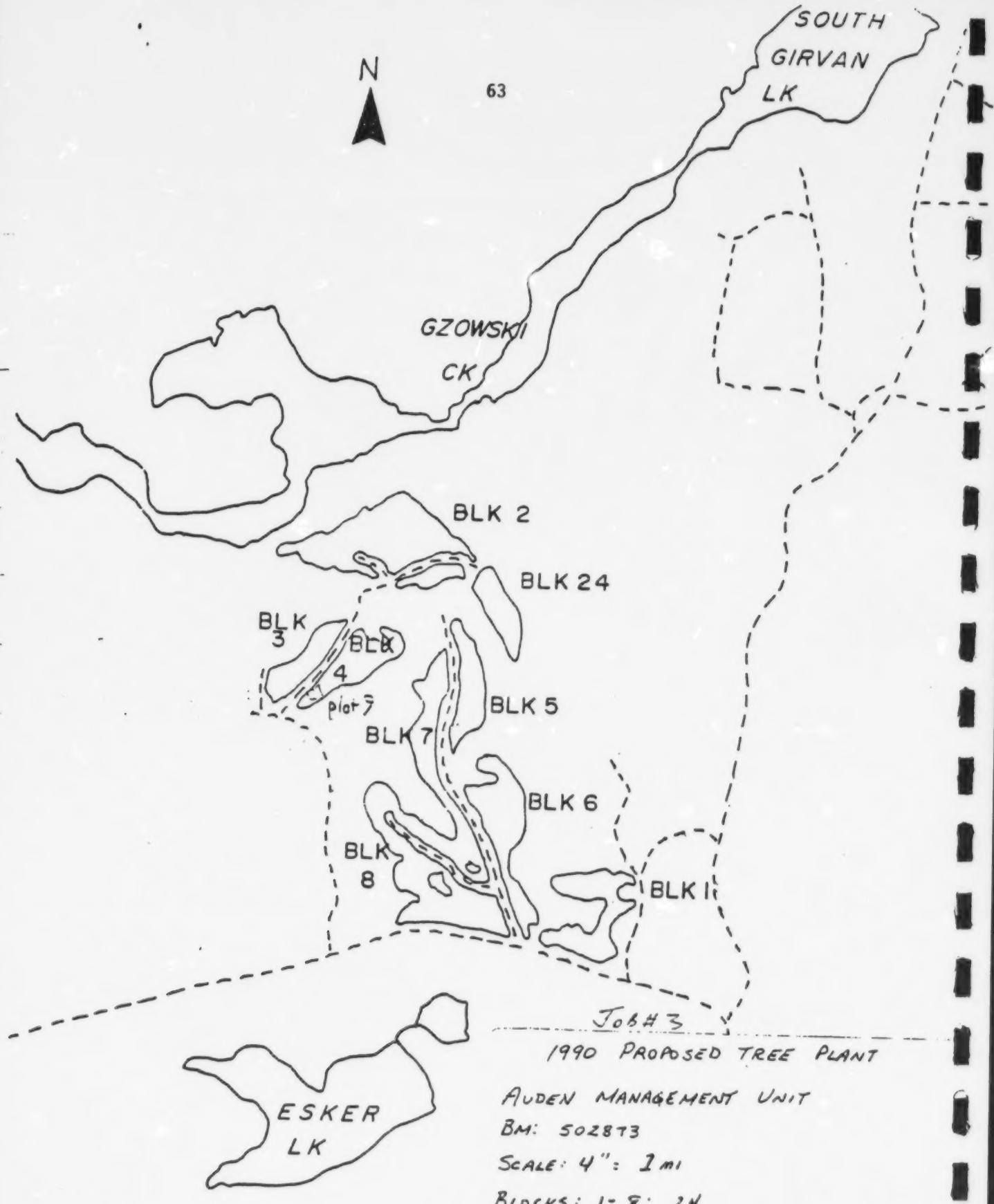
(7) Column (7) refers to the type of operation: hand (h), machine (m), refill (r), spraying (s), referred to in column (1), attached hereto.

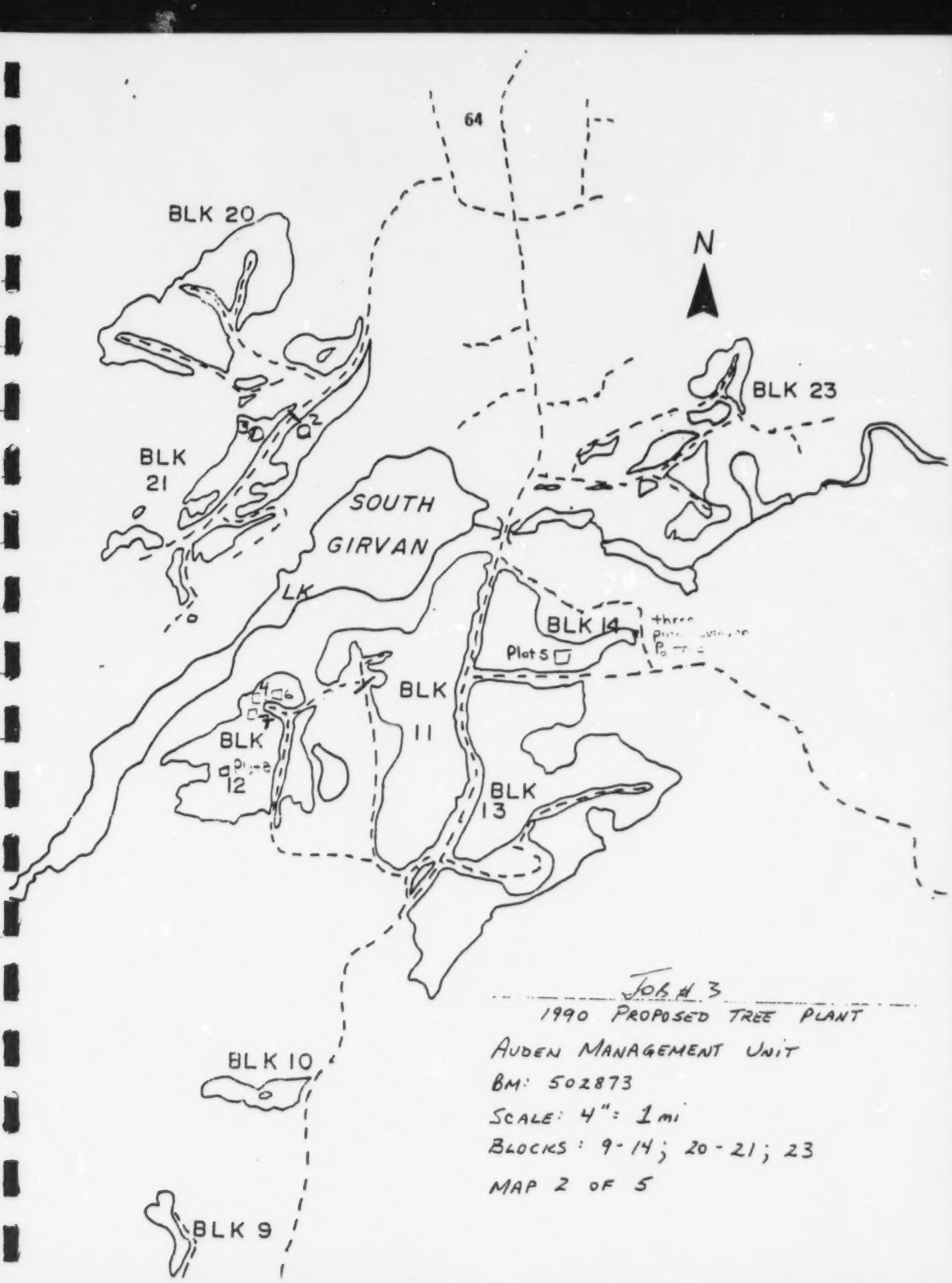
SCHEDULE "A" (continued)

1	2		3			4	5			6	7
Planting Area	Target Dates Commencement	Completion	STOCK Species	Type	Age	SPACING min. (incl nat regen)	DENSITY Min.	Target	Max.	AREA ha.	TYPE OPER. (h)(m)(r)(s)
Blk 1	May 14	June 15	Pj	C/S	O.W.	1.8 m	1995	2100	2310	3.6	(h)
Blk 2			Pj	C/S	O.W.		1995	2100	2310	8.5	
Blk 3			Sw	B/R	2+2		1330	1400	1540	2.6	
Blk 4			Sb	B/R	1½+1½		1615	1700	1870	3.5	
Blk 5			Sb	B/R	1½+1½		1900	2000	2200	3.0	
Blk 6			Sw	B/R	2+2		1615	1700	1870	4.4	
Blk 7			Sb	B/R	1½+1½		1520	1600	4760	9.9	
Blk 8			Sw	B/R	2+2		1425	1500	1650	7.3	
Blk 9			Sb	B/R	1½+1½		1805	1900	2190	1.7	
Blk 10			Sb	B/R	1½+1½		2185	2300	2530	3.0	
Blk 11			Pj	C/S	O.W.		1235	1300	1430	27.9	
Blk 12			Sb	B/R	1½+1½		1425	1500	1650	11.8	
Blk 13			Pj	C/S	O.W.		1425	1500	1650	30.6	
Blk 14			Sb	B/R	1½+1½		1330	1400	1540	7.9	
Blk 15			Sb	B/R	1½+1½		1045	1100	1210	25.5	
Blk 16			Sw	B/R	2+2		1140	1200	1320	15.5	
Blk 17			SW	B/R	2+2		950	1000	1100	15.2	
Blk 18			Sw	B/R	2+2		1140	1200	1320	15.5	
Blk 19			Pj	C/S	O.W.		1330	1400	1540	14.4	
Blk 20			Pj	C/S	O.W.		1100	1000	950	12.6	
Blk 21			Sb	B/R	1½+1½		1425	1500	1650	12.8	
Blk 22			Sb	B.R	1½+1½		950	1000	1100	6.9	
Blk 23			Pj	C/S	O.W.		1425	1500	1650	8.0	
Blk 24			Sb	B/R	1½+1½		1235	1300	1430	2.8	
Blk 25			Pj	C/S	O.W.		1330	1400	1540	15.0	
Blk 26			Pj	C/S	O.W.		1710	1800	1980	14.0	



1990 Proposed Tree Plant Blocks
Auden Management Unit
BM 502873
Scale: 1" = 2 mi.


N
63
SOUTH
GIRVAN
LK
GZOWSKII
CK
BLK 2
BLK 24
BLK
3
BLK
4
plot 7
BLK 5
BLK 7
BLK 6
BLK
8
BLK 1
ESKER
LK
Job #3
1990 PROPOSED TREE PLANT
AUDEN MANAGEMENT UNIT
BM: 502873
SCALE: 4": 1 mi
BLOCKS: 1-8; 24
MAP 1 OF 5



Job # 3

1990 PROPOSED TREE PLANT

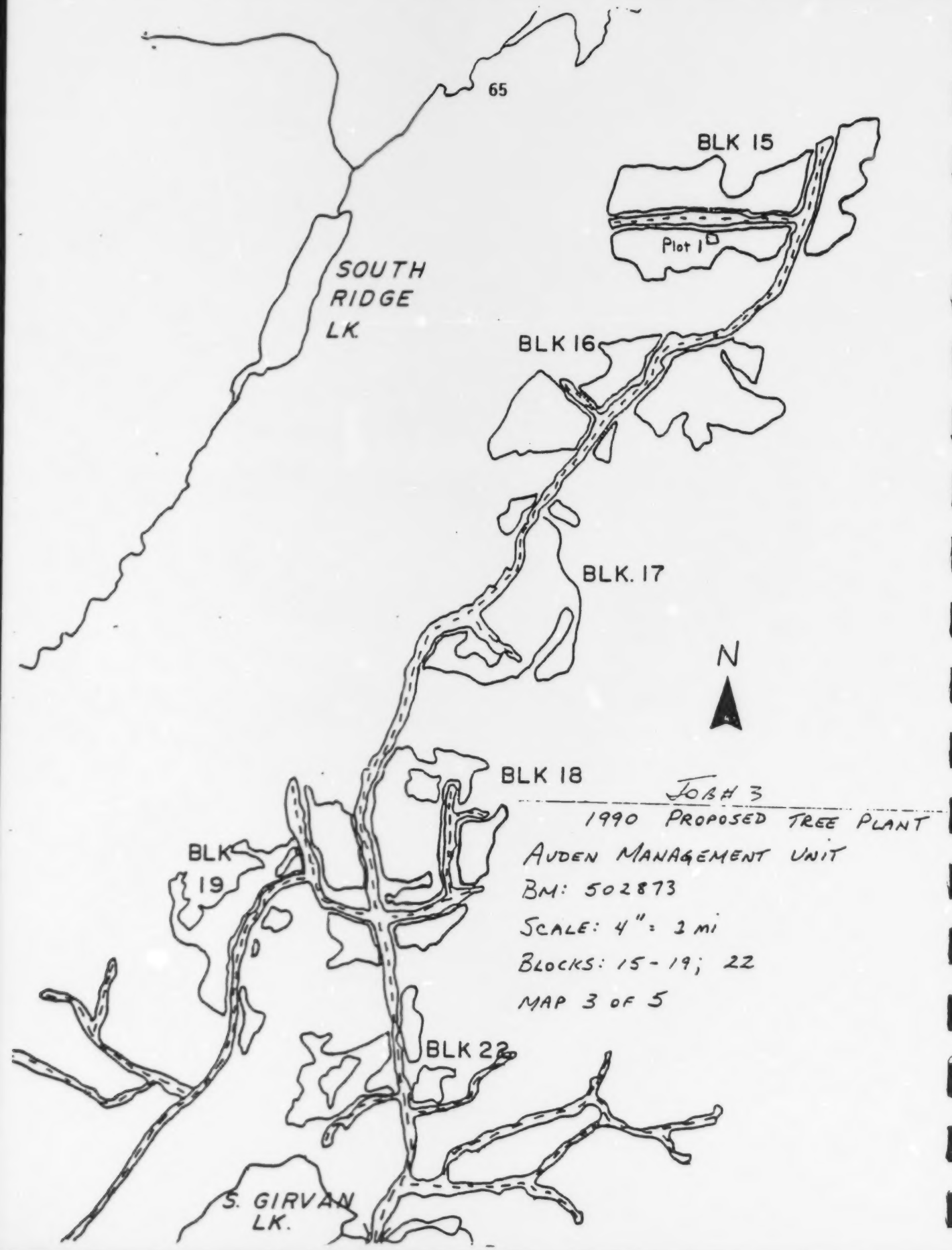
AUDEN MANAGEMENT UNIT

BM: 502873

SCALE: 4" = 1 mi

BLOCKS: 9-14; 20-21; 23

MAP 2 OF 5



JOB # 3

1990 PROPOSED TREE PLANT

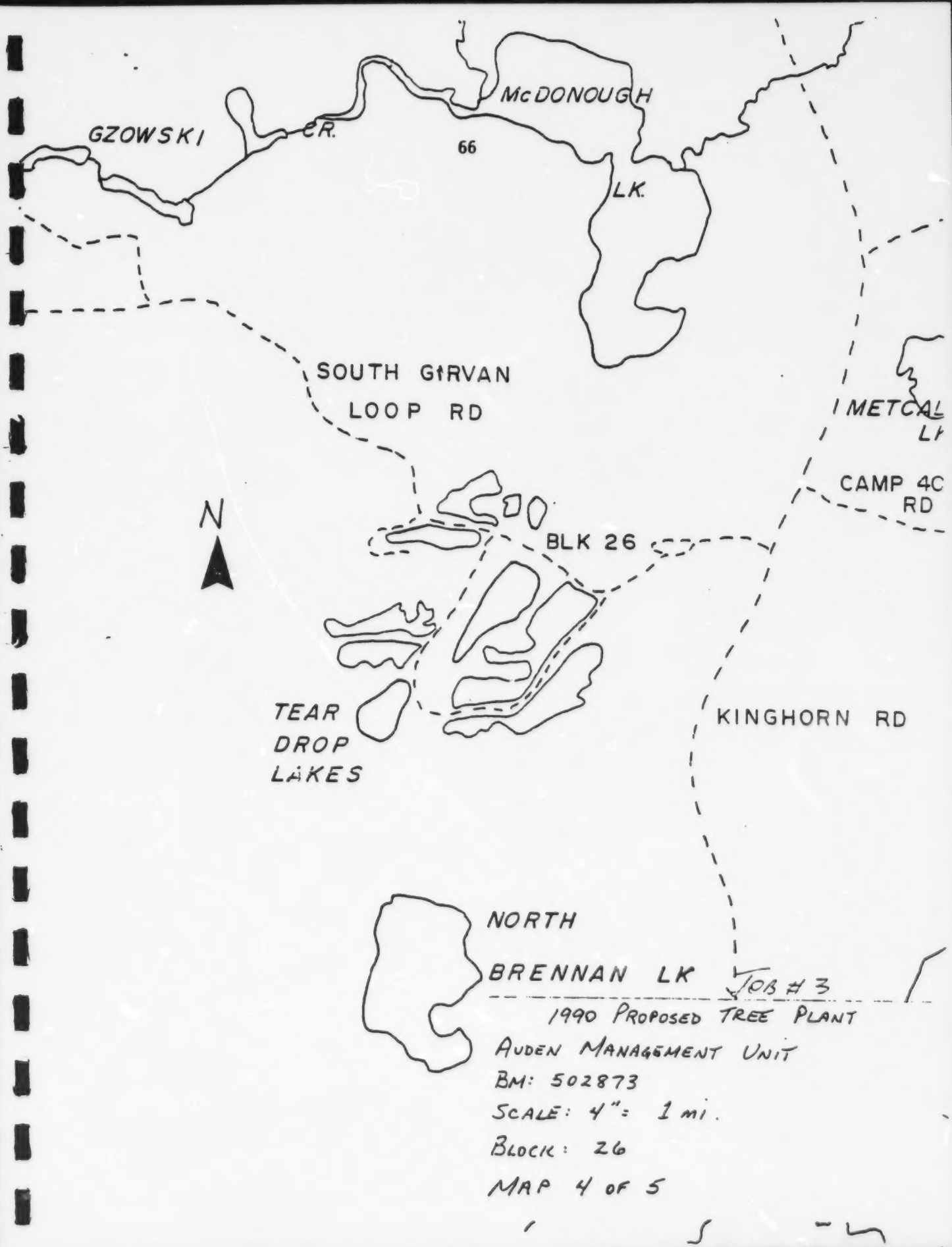
AUDEN MANAGEMENT UNIT

BM: 502873

SCALE: 4" = 1 mi

BLOCKS: 15 - 19; 22

MAP 3 OF 5


McDONOUGH
GZOWSKI
CR.
66
LK.
SOUTH GIRVAN
LOOP RD
METCAL
LI
CAMP 4C
RD
N
BLK 26
TEAR
DROP
LAKES
KINGHORN RD
NORTH
BRENNAN LK
JOB # 3
1990 PROPOSED TREE PLANT
AUDEN MANAGEMENT UNIT
BM: 502873
SCALE: 4" = 1 mi.
BLOCK: 26
MAP 4 OF 5

JOB # 3

1990 PROPOSED TREE PLANT

AUDEN MANAGEMENT UNIT

BM: 502873

SCALE: 4" = 1 mi.

BLOCK: 25

MAP 5 OF 5

▨ - AREA TO BE PLANTED

APPENDIX IV

Daily Account of Harvester Operating

Times and Description of Mechanical Breakdowns

For the Fall 1990 Bulk Lift

Mechanical Bulk Harvester Operating Times,
Thunder Bay Forest Nursery
Fall 1990.

October 23

Start	1:00 p.m.
Finish	3:36 p.m. breakdown
Available Time	2 hrs. 36 min.
Lunch break	30 min.
(Net) Operating time	2 hrs. 6 min.

October 24

Start	11:00 a.m.
Finish	5:03 p.m. breakdown
Total Time	6 hrs. 3 min.
Breakdowns	1 hr. 50 min.
	22 min.
Available Time	3 hrs. 51 min.
Lunch	30 min.
Coffee	11 min.
(Net) Operating Time	3 hrs. 10 min.

October 26

Start	10:00 a.m.
Finish	5:15 p.m. Completed Lift
Available Time	7 hrs. 15 min.
Lunch break	30 min.
Coffee	16 min.
(Net) Operating Time	6 hrs. 29 min.

Total Time	18 hrs. 54 min	
Repair Time	5 hrs. 12 min.	
Total Available Time	13 hrs. 42 min.	
Total (Net) Operating Time	11 hrs. 45 min.	
Total Cost Time	17 hrs. 24 min.	excluded lunch breaks from total time.

Breakdowns: 1. Belt came completely off of pulley at upper end of system. Machine operated for approximately 30 seconds before the missing belt was noted. This was noted by myself and not one of the contractor's staff.
Repair time : 2 hours.

2. Belt face separated from the part in the pulley. Belt had to be replaced.
Repair time : 1 hr. 50 min.

3. Belt groove filled up with dirt and started to come off. Machine was stopped before belt could come completely off. This made the repair easier and much less time consuming. A scraper was adjusted to alleviate the problem.
Repair time : 22 min.

4. Bolt connecting shaker to drive device was sheared. this required that a new bolt be installed. A plastic bushing to decrease wear was added at the same time.
Repair time : 1 hour.

APPENDIX V

Seedling Counts and Cull Assessment Data

For The 1990 Fall Bulk Lifted Stock From

Compartments 48 and 58

Mechanical Bulk Harvest Box Counts (Fall 1990; compartment 58)

Box #	Number of Seedlings	Number of Cull Seedlings	Size		Growth Deformities		Physical Abnormalities or Damage**						Cull (%)	Box Weight (kg)	Soil Weight (kg)	Percent Soil
			Ht	Rcd	Root System	Misformed Trees	i	ii	iii	iv	v	vi				
1	183	19	7	0	8	3	0	0	2	3	0	0	10.38	23.59	4.99	21.15
2	175	11	3	0	4	0	1	0	0	3	0	0	6.29	23.13	3.18	30.26
3	140	11	1	0	6	0	2	1	0	1	0	0	7.86	33.57	9.07	59.58
4	161	10	1	0	1	1	1	1	0	5	0	0	6.21	30.39	5.90	42.78
5	167	28	10	0	15	2	0	1	0	2	0	0	16.77	35.38	21.32	132.84
6	159	19	2	0	6	0	1	1	0	9	0	0	11.95	29.94	13.15	96.87
7	130	17	3	0	12	1	0	0	1	3	0	0	13.08	22.23	10.43	103.48
8	181	20	10	0	7	0	1	1	1	2	0	0	11.05	21.32	9.98	103.19
9	146	7	3	0	3	0	0	0	1	0	1	0	4.79	32.21	18.60	57.75
10	195	9	3	0	2	2	0	0	0	2	0	0	4.62	31.30	16.33	52.17
11	176	12	1	0	7	0	0	3	0	1	0	0	6.82	33.57	19.05	56.76
12	295	29	6	0	21	3	0	0	0	5	0	0	9.83	21.77	5.44	25.00
13	255	21	0	0	12	3	1	0	0	6	0	0	8.24	26.76	7.26	27.12
14	250	17	1	0	8	1	1	2	0	5	0	0	6.80	30.39	12.25	40.30
15	195	9	0	0	2	3	1	0	0	3	0	0	4.62	24.04	7.26	30.19
16	207	48	4	0	41	2	2	0	1	1	0	0	23.19	31.30	16.78	53.62
17	249	27	0	0	17	3	0	2	0	6	0	0	10.84	22.68	5.90	26.00
18	236	7	0	0	7	0	0	0	0	0	0	0	2.97	27.67	10.43	37.70
19	268	31	7	0	16	3	0	1	0	7	0	0	11.57	22.23	6.35	28.57
20	191	8	3	0	2	0	0	0	0	3	0	0	4.19	27.67	11.79	42.62
21	186	15	4	0	9	0	1	0	0	2	0	0	8.06	20.87	7.71	36.96
22	188	14	4	0	3	0	1	3	0	3	0	0	7.45	29.48	13.61	46.15
23	214	11	4	0	4	0	1	0	0	3	0	0	5.14	26.76	11.34	42.37
24	178	8	1	0	3	0	0	0	0	4	0	0	4.49	25.40	11.34	44.64
25	201	8	2	0	2	1	0	0	0	3	0	0	3.98	26.76	11.34	42.37
Total	4926	416	80	0	218	28	14	16	6	82	1	0		680.39	247.66	
Average	197.04	16.64	3.2	0	8.72	1.12	0.56	0.64	0.24	3.28	0.04	0	8.45	27.22	11.79	53.65
S.D.	40.70	9.63	2.83	0.00	8.45	1.24	0.64	0.93	0.51	2.15	0.20	0.00	4.48	4.28	4.42	29.11
Percent of Total		8.44	1.62	0.00	4.43	0.57	0.28	0.32	0.12	1.66	0.02	0.00				
Percent of Total Cull			19.23	0.00	52.40	6.73	3.37	3.85	1.44	19.71	0.24	0.00				

** For explanation refer to Appendix I, 2.2b.

Mechanical Bulk Harvest Box Counts (Fall 1990; compartment 48)

Box #	Number of Seedlings	Number of Cull Seedlings	Size		Growth Deformities		Physical Abnormalities or Damage**						Cull (%)	Box Weight (kg)	Soil Weight (kg)	Percent Soil
			Ht	Rcd	Root System	Misformed Trees	i	ii	iii	iv	v	vi				
1	152	10	3	0	4	0	2	1	0	1	0	0	6.58	34.02	23.13	68.00
2	157	3	0	0	1	0	2	0	0	1	0	0	1.91	37.19	24.49	65.85
3	157	20	1	0	13	1	3	1	0	2	0	0	12.74	37.65	25.85	68.67
4	190	13	1	0	3	4	1	0	0	4	0	0	6.84	39.01	26.31	67.44
5	179	17	1	0	11	0	0	3	0	3	0	0	9.50	35.38	19.96	56.41
6	166	15	2	0	9	0	0	0	0	5	0	0	9.04	36.74	23.59	64.20
7	158	17	5	0	12	0	0	1	0	2	0	0	10.76	34.47	23.59	68.42
8	151	12	3	0	6	1	0	0	0	3	0	0	7.95	34.47	23.13	67.11
Total	1310	107	16	0	59	6	8	6	0	21	0	0		288.94	90.26	
Average	163.75	13.375	2	0	7.375	0.75	1	0.75	0	2.625	0	0	8.16	36.12	22.57	64.03
S.D.	13.00	4.92	50	0.00	4.21	1.30	1.12	0.97	0.00	1.32	0.00	0.00	3.03	1.68	1.52	4.66
Percent of Total		8.17	1.22	0.00	4.50	0.46	0.61	0.46	0.00	1.60	0.00	0.00				
Percent of Total Cull			14.95	0.00	55.14	5.61	7.48	5.61	0.00	19.63	0.00	0.00				

** For explanation refer to Appendix I, 2.2b.

Seedling counts per box and cull assessments.
Mechanical Bulk Lift. Compartment 58.
Source: Lucy Tower, Thunder Bay Forest Nursery

Box #	Number of Seedlings	Number of Seedlings Damaged From Packaging	Box Appearance Code*	Undersize Seedlings	Deformed Roots 'J-roots'	Broken Tops	Stripped Roots	Too Few Roots	Squashed Stems From Belts	Damaged Cambium
1	267	21	2	22	83	18	1	0	203	29
2	302	16	3	53	23	27	3	22	287	14
3	177	7	3	34	49	20	3	9	148	20
4	184	18	3	17	36	17	0	11	166	18
5	202	9	2	33	24	29	0	0	202	3
6	260	8	2	12	27	22	0	0	241	11
7	194	4	2	6	39	7	11	2	183	8
8	256	11	3	46	40	12	2	0	211	18
9	194	3	3	16	22	10	0	0	173	2
10	218	8	3	16	28	12	0	0	204	0
11	178	13	3	27	18	2	0	6	153	21
12	152	11	2	41	12	6	0	0	140	17
13	237	11	2	36	29	5	0	1	197	0
14	209	6	2	30	22	0	1	2	127	13
15	170	19	2	19	18	11	0	0	194	4
16	183	3	3	11	36	19	0	3	150	0
17	181	8	2	18	29	2	1	3	142	27
18	244	6	3	47	11	0	1	0	202	1
Sum	3808	182	45	484	546	219	23	59	3323	206
Mean	212	10	3	27	30	12	1	3	185	11

*codes

1 - tidy; Seedlings end to end.
2 - moderate; very small percentage of seedlings sprayed out in box.
3 - messy; most of box very unkempt.

APPENDIX VI

Seedling Counts and Cull Assessment

Data For The 1990 Spring Mechanically

and Manually Bulk Lifted Stock

Mechanical Bulk Harvest Box Counts

Box #	Number of Seedlings	Number of Cull Seedlings	Size		Growth Deformities		Physical Abnormalities or Damage**						Cull (%)
			Ht	Rcd	Root System	Misformed Trees	i	ii	iii	iv	v	vi	
1	180	23	3	0	15	0	0	4	0	4	1	0	12.78
2	210	27	1	0	17	0	0	7	1	1	2	0	12.86
3	244	26	6	0	13	0	0	6	0	2	1	0	10.66
4	197	28	1	0	17	0	0	6	0	5	0	0	14.21
5	154	9	1	0	1	0	2	2	0	3	0	0	5.84
6	152	25	1	1	2	3	9	0	0	10	1	1	16.45
7	146	21	2	1	5	1	0	7	1	3	2	0	14.38
8	171	26	0	0	8	0	7	2	2	8	0	0	15.20
9	166	12	0	0	7	2	0	1	0	3	0	0	7.23
10	150	13	1	0	3	1	0	2	1	5	1	0	8.67
11	203	45	1	0	20	0	5	2	1	20	0	0	22.17
12	186	20	3	0	2	0	0	10	0	4	2	0	10.75
13	128	14	0	0	1	0	0	0	0	13	0	0	10.94
14	119	21	0	0	2	0	2	0	0	17	0	0	17.65
15	170	22	1	0	9	3	0	0	2	8	2	0	12.94
16	148	34	0	0	0	0	4	0	0	29	0	0	22.97
17	166	20	0	0	6	0	0	4	0	10	0	0	12.05
18	180	34	1	0	16	1	3	2	0	13	0	0	18.89
19	210	33	2	0	2	1	13	4	9	10	0	0	15.71
20	213	17	2	0	5	0	0	5	0	7	0	0	7.98
Total	3493	470	26	2	151	12	45	64	17	175	12	1	
Average	174.65	23.5	1.3	0.1	7.55	0.6	2.25	3.2	0.85	8.75	0.6	0.05	13.52
S.D.	30.66	8.50	1.42	0.30	6.30	0.97	3.58	2.82	1.98	6.81	0.80	0.22	4.51
Percent of Total		13.46	0.74	0.06	4.32	0.34	1.29	1.83	0.49	5.01	0.34	0.03	
Percent of Total Cull			5.53	0.43	32.13	2.55	9.57	13.62	3.62	37.23	2.55	0.21	

** For explanation refer to Appendix I, 2.2b.

Manual Bulk Harvest Box Counts

Box #	Number of Seedlings	Number of Cull Seedlings	Size		Growth Deformities		Physical Abnormalities or Damage**						Cull (%)
			Ht	Rcd	Root System	Misformed Trees	i	ii	iii	iv	v	vi	
1	180	23	3	0	15	0	0	4	0	4	1	0	12.78
1	180	15	1	1	2	1	2	1	2	8	0	1	8.33
2	156	13	1	0	0	9	3	0	0	2	0	0	8.33
3	111	6	0	0	1	7	3	0	0	0	0	0	5.41
4	155	12	0	0	5	3	1	1	0	2	0	0	7.74
5	121	11	0	0	3	3	0	3	0	3	0	0	9.09
6	120	15	0	0	2	13	3	0	0	0	0	0	12.50
7	146	13	0	0	1	1	3	0	0	8	0	0	8.90
8	176	33	5	2	22	0	0	1	0	11	1	0	18.75
9	139	19	1	1	2	2	10	0	0	4	1	1	13.67
10	109	7	0	0	1	0	3	0	0	4	0	0	6.42
11	150	18	0	1	7	1	0	3	0	1	3	3	12.00
12	181	19	0	0	2	8	1	0	0	5	2	1	10.50
13	151	16	0	0	8	3	0	3	0	0	1	1	10.60
14	132	12	0	0	5	1	0	4	0	0	2	0	9.09
15	191	21	0	0	5	5	4	1	0	6	0	0	10.99
16	132	5	0	0	3	1	0	1	0	0	0	0	3.79
17	124	5	0	0	2	0	0	1	0	0	2	0	4.03
18	90	14	0	0	8	1	0	0	0	2	4	0	15.56
19	195	9	0	0	2	0	0	2	0	5	0	0	4.62
20	126	15	0	0	5	1	2	0	0	7	0	0	11.90
Total	2885	278	8	5	86	60	35	21	2	68	16	7	
Average	144.25	13.9	0.4	0.25	4.3	3	1.75	1.05	0.1	3.4	0.8	0.35	9.61
Percent		9.64	0.28	0.17	2.98	2.08	1.21	0.73	0.07	2.36	0.55	0.24	
Percent of Total Cull			2.88	1.80	30.94	21.58	12.59	7.55	0.72	24.46	5.76	2.52	

** For explanation refer to Appendix I, 2.2b.

APPENDIX VII

Spring and Fall Conventional Lift Costs

and Cost Model For

The Conventional Lift - Per Tree Plant

CONVENTIONAL LIFT COSTS, SPRING 1990

Assumptions

Contractor costs are an estimate only. Salary estimates are based on the staffing and productivity data provided by the Thunder Bay Forest Nursery.

MNR costs were provided by the Thunder Bay Forest Nursery.

Rates for equipment are calculated from monthly rates by dividing the rate by 26 working days per month and multiplying by the number of days used. (15 for conventional lift)

Contractor Costs

Lifters: For 1st 3 days were paid $15.00/1000 seedlings.

For remainder of contract were paid 12.89/hr + bonus. Bonus payments were variable and therefore could not calculated into the costs.

Support Staff: Table Crew, Support Staff, Box Makers and Tally Persons were all paid $11.88/hr + 8.5% vacation and holiday pay = $12.89/hr.

Supervisors: A wage of $14.25/hr + 8.5% vac. pay = $15.46/hr was applied to supervisors.

Days 1-3:	1,597,550 seedlings lifted	$ 23,963.25
	Manual workers 1907 man hrs @ $12.89/hr	$ 24,581.23
	Supervisors 161 mh @ $15.46/hr	$ 2,489.06
Days 4-15:	Manual workers 15,542.25mh @ $12.89/hr	$200,339.60
	Supervisors 603.75 mh @ $15.46/hr	$ 9,333.98
		$260,707.12
Benefits:	(UIC 1.4%, CPP 2.2%, EHB 1.95%, WCB 4.65%; Total = 10.2%)	$ 26,592.13
	Employee Costs	$287,299.25

Equipment Rented from MNR:	electric staplers	$ 1.00
	4 - 4 wheel wagons	$ 1.00
	4 - 2 wheel water wagons	$ 1.00
	Plastic tubs	$ 0.00
		$ 3.00

Other Equipment:

4 ½ ton pickup trucks $800.00/mo. ea.	$ 1,846.15
4 ATVs w/ trailers $250.00/mo. ea.	$ 576.92
1 1 ton stake truck $1250.00/mo. ea.	$ 721.15
2 School buses $0.73/km (5 km/day)	$ 109.50
1 Office Trailer $160/mo.	$ 92.31
1 Telephone (install. $27 + $18/mo.)	$ 37.38
8 Portable Toilets $100/mo. ea.	$ 461.54
2 Storage Vans for boxes $175/mo.	$ 201.92
	$ 4,046.87
Total Contractor Cost	$291,349.12
Bid Price $45.61/1000 seedlings	$372,000.59
(Profit Margin - 27.7%)	
Liquidated damages assessed to contractor -	$ 8,282.08
	$363,718.51

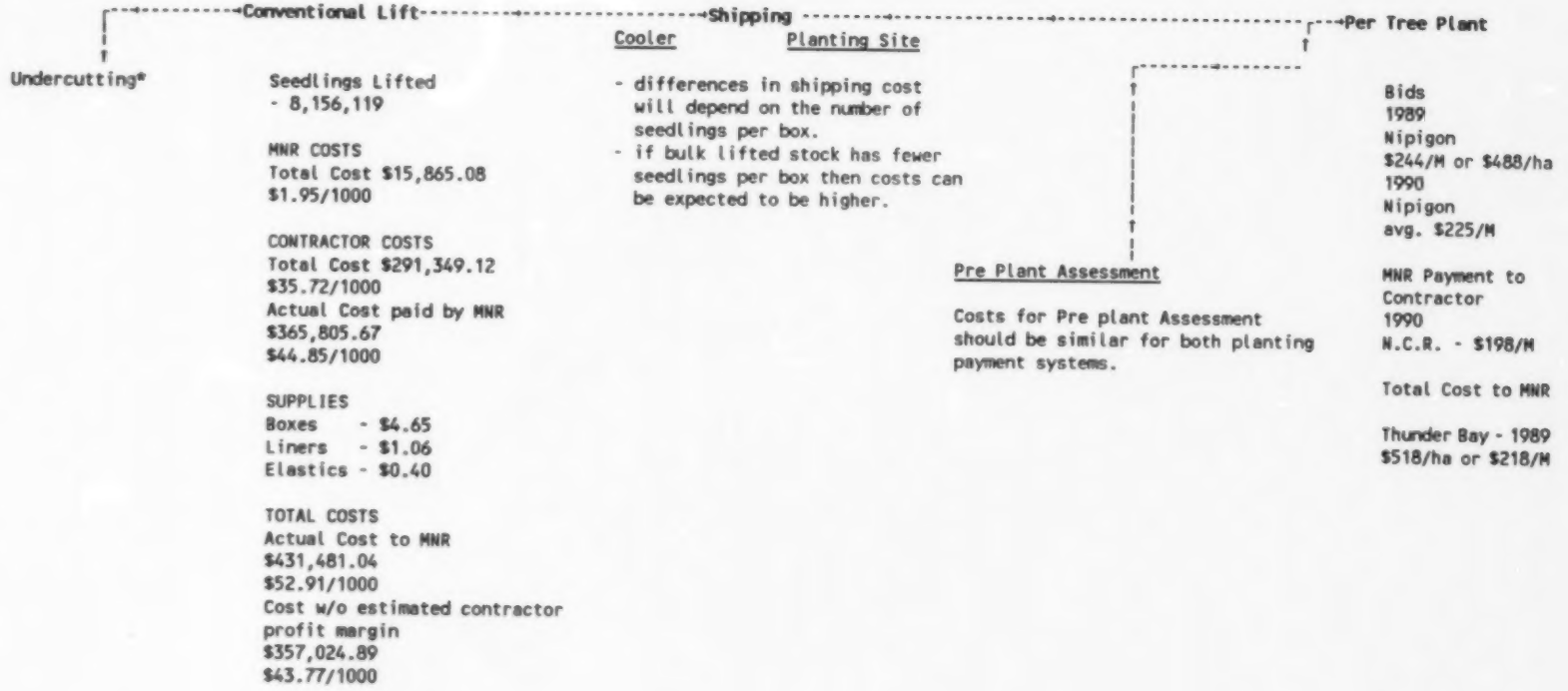
MNR Costs

Actual Cost paid by MNR to contractor ($44.85/ 1000 seedlings)	$365,805.67
MNR 'B' Salary	$ 13,358.40
A.E. (2 ½ ton trucks, 1 minivan, 3 tractors, 3 egedals)	$ 2,506.68
Boxes (40,305 @ $0.94 ea.)	$ 37,886.70
Liners ($218.00/1000)	$ 8,661.54
Elastics	$ 3,262.45
Total MNR Costs	$431,481.04

Total seedlings lifted: 8,156,119

MNR Cost/1000	$ 52.91
Approximate Cost/1000 w/o contractor's profit margin	$ 43.77

Cost Analysis of the Spring Conventional Lift - Conventional Per Tree Plant.



Contractor costs are estimates only. MNR costs were provided by the Thunder Bay Forest Nursery for the 1990 spring seedling lift.

*Undercutting costs are included in the MNR costs for the conventional lift.

CONVENTIONAL LIFT COSTS, FALL 1990

Assumptions

Contractor costs are an estimate only. Salary estimates are based on the staffing and productivity data provided by the Thunder Bay Forest Nursery.

MNR costs were provided by the Thunder Bay Forest Nursery.

Rates for equipment are calculated from monthly rates by dividing the rate by 26 working days per month and multiplying by the number of days used. (10 for conventional lift)

Contractor Costs

Lifters: For 1st 3 days were paid $15.00/1000 seedlings. For remainder of contract were paid 12.89/hr + bonus. Bonus payments were variable and therefore could not calculated into the costs.

Support Staff: Table Crew, Support Staff, Box Makers and Tally Persons were all paid $11.88/hr + 8.5% vacation and holiday pay = $12.89/hr.

Supervisors: A wage of $14.25/hr + 8.5% vac. pay = $15.46/hr was applied to supervisors.

Days 1-3:	2,493,550 seedlings lifted	$ 37,403.25
	Manual workers 2148 man hrs @ $12.89/hr	$ 27,687.72
	Supervisors 138 mh @ $15.46/hr	$ 2,133.48
Days 4-10:	Manual workers 10,211mh @ $12.89/hr	$131,619.79
	Supervisors 288 mh @ $15.46/hr	$ 4,452.48
		$203,296.72
Benefits (UIC 1.4%, CPP 2.2%, EHB 1.95%, WCB 4.65%; Total = 10.2%)		$ 20,736.27
	Employee Costs	$224,032.99

Equipment Rented from MNR:	4 electric staplers	$ 1.00
	4 - 4 wheel wagons	$ 1.00
	Rakes, cleavers, extension cords, forks, brooms	$ 1.00
	Plastic tubs	$ 676.00
		$ 679.00

Other Equipment:

3 ½ ton pickup trucks $800.00/mo. ea.	$ 923.08
5 ATVs w/ trailers $250.00/mo. ea.	$ 480.77
2 1 ton stake truck $1250.00/mo. ea.	$ 961.54
2 School buses $0.73/km (5 km/day)	$ 73.00
1 Office Trailer $160/mo.	$ 61.54
1 Telephone (install. $27 + $18/mo.)	$ 33.92
8 Portable Toilets $100/mo. ea.	$ 307.69
2 Storage Vans for boxes $175/mo.	$ 134.62
	$ 2,976.16
Total Contractor Cost	$227,688.15
Bid Price $45.89/1000 seedlings	$335,490.77
(Profit Margin - 47.7%)	

MNR Costs

Actual Cost paid by MNR to contractor ($45.89/ 1000 seedlings)	$335,490.77
Liquidated damages assessed to contractor	- $ 1,500.00
Equipment Rental Charges	- $ 679.00
Bonus to contractor for early completion	$ 1,000.00
Total Payment to Contractor	$334,311.77
MNR 'B' Salary	$ 20,090.52
A.E. (2 ½ ton trucks, 1 minivan, 3 tractors, 3 egedals)	$ 2,384.62
Boxes (21,694 @ $0.94 ea.)	$ 20,392.36
Liners ($190.00/1000)	$ 4,121.86
Elastics (645,338 @ $2.89/1000)	$ 1,861.83
Staples	$ 1,278.86
Total MNR Costs	$384,441.82
Total seedlings lifted: 7,310,760	
MNR Cost/1000	$ 52.59
Approximate Cost/1000 w/o contractor's profit margin	$ 38.14

Cost Analysis of the Fall Conventional Lift - Conventional Per Tree Plant.

Conventional Lift → **Shipping** → **Per Tree Plant**

Undercutting*

Seedlings Lifted
- 7,310,760

MNR COSTS
Total Cost $22,475.14
$3.07/1000

CONTRACTOR COSTS
Total Cost $227,688.15
$31.14/1000
Actual Cost paid by MNR
$334,311.77
$45.73/1000

Total Cost to MNR
SUPPLIES
Boxes - $2.79
Liners - $0.56
Elastics - $0.25
Staples - $0.17

TOTAL COSTS
Actual Cost to MNR
$384,441.82
$52.59/1000
Cost w/o estimated contractor profit margin
$277,818.20
$38.00/1000

Shipping

Cooler

- differences in shipping cost will depend on the number of seedlings per box.
- if bulk lifted stock has fewer seedlings per box then costs can be expected to be higher.

Planting Site

Pre Plant Assessment

Costs for Pre plant Assessment should be similar for both planting payment systems.

Per Tree Plant

Bids
1989
Nipigon
$244/M or $488/ha
1990
Nipigon
avg. $225/M

MNR Payment to Contractor
1990
N.C.R. - $198/M

Thunder Bay - 1989
$518/ha or $218/M

Contractor costs are estimates only. MNR costs were provided by the Thunder Bay Forest Nursery for the 1990 spring seedling lift.

*Undercutting costs are included in the MNR costs for the conventional lift.

APPENDIX VIII

Spring and Fall Bulk Lift Costs and Cost Model

For The Combined Bulk Lift - Area Base Plant

BULK LIFT COSTS, SPRING 1990

Assumptions

The bulk lift is a separate operation and there is no cross over between the bulk and the conventional lifts in terms of staff or equipment.

The machine was used for 1½ days equating to 12 hours.

A standard work day is 8 hours with two 15 minute coffee breaks for a total of 7.5 working hours.

Rates for equipment are calculated from monthly rates by dividing rate by 26 working days per month and multiplying by the number of days used. (1.5 for bulk lift)

Bulk lift costs

1) Root Pruning - 2 hours		
- tractor w/ vertical root pruner $8.00/hr		$ 16.00
- operator 1) RT2 $17.19/hr		$ 34.38
2) RT1 $15.58/hr		$ 31.16
		$ 81.54
2) Undercutting with belly blade		
- 1 hour (13,000 seedlings)		
- 3 hours (144,000 seedlings)	13,000	144,000
- tractor w/ belly blade $8.00/hr	$ 8.00	$ 24.00
- operator 1) RT1 $15.58/hr	$ 15.58	$ 46.74
	$ 23.58	$ 70.74
3) Bulk Lift - 12 hours		
- tractor w/ belt harvester $8.00/hr		$ 96.00
- operator 1) RT2 $17.19/hr		$ 206.28
2) RT1 $15.58/hr		$ 186.96
- supervisor RT2 $16.39/hr		$ 196.68
- quality assessor RT1 $15.17/hr		$ 182.04
- minivan - $870/mo.		$ 50.19
- mechanic - 6 hours @ $18.40/hr		$ 110.40
- MNR staff at shipping barn RT1 $15.17/hr		$ 182.04
		$1,210.59

4) Contractor costs

- manual workers (9) @ $12.89/hr * 12 hrs		$1,392.12
- box makers (2) @ $12.89/hr		$ 309.36
- loader (1) @ $12.89/hr		$ 154.68
- unloaders (2) @ $12.89/hr		$ 309.36
- truck drivers (2) @ $12.89/hr		$ 309.36
- supervisor (1) @ $15.46/hr		$ 185.52
- Benefits (UIC 1.4%, CPP 2.2%, EHB 1.95%, WCB 4.65%, tot= 10.2%)		$ 271.36
- Half ton pickup (2) rate $744/month + mileage + fuel = $800/mo.		$ 92.31
- Office Trailer ($160/mo.)		$ 9.23
- Portable Toilets ($100/mo.)		$ 5.77
- Telephone (install. $27 + $18/mo.)		$ 28.04
- Storage Vans for boxes ($175/mo. ea.)		$ 10.10
Contractor Cost		$3,077.21
- contractor's profit margin above costs - 30%	X 1.30	$4,000.37

Cost per 1000 based on actual # seedlings harvested in 1½ days - 13,000 $ 408.92

Cost per 1000 based on estimated productivity - 96,000/day or 144,000 in 1½ days $ 37.25

Supplies

- boxes 3.76 ea/4 yr = 0.94 ea/yr		
13,000 - 75 boxes	$ 70.50	
144,000 - 825 boxes	$ 775.50	
cost per 1000 seedlings		$ 5.38
- liners $218/1000		
13,000 - 75 boxes	$ 16.35	
144,000 - 825 boxes	$ 179.85	
cost per 1000 seedlings		$ 1.25

Total Cost per 1000 for 13,000 seedlings $ 415.55

Total Cost per 1000 for 144,000 seedlings $ 43.88

Without Estimated Contractor Profit Margin

Total Cost $4287.80

Total Cost per 1000 for 13,000 seedlings $ 344.54

Total Cost per 1000 for 144,000 seedlings $ 37.47

Cost Analysis of a Combined Bulk Lift - Area Base Plant.

Bulk Lift → **Shipping** → **Area Base Plant**

Undercutting
13,000 seedlings
$1.81/1000
144,000 seedlings
$0.49/1000

Root Pruning
Vert. & Hor.
Total Cost $81.54
13,000 seedlings
$6.27/1000
144,000 seedlings
$0.57/1000

MNR COSTS
Total Cost $1210.59
13,000 seedlings
$93.12/1000
144,000 seedlings
$8.41/1000

CONTRACTOR COSTS w/ 30% Profit Margin
Total Cost $4000.37
13,000 seedlings
$307.72/1000
144,000 seedlings
$27.78/1000

SUPPLIES
Boxes - $5.38/1000
Liners - $1.25/1000

TOTAL COSTS
$5,210.96
13,000 seedlings
$407.47/1000
144,000 seedlings

$42.82/1000

Shipping

Cooler

- changes in shipping cost will depend on the number of seedlings in a box.
- if less than number per box for conventional lift then shipping bulk lifted stock will cost more.

Planting Site

Pre Plant Assessment

Costs for Pre plant Assessment should be similar for both planting payment systems.
Costs to the contractor for laying out the planting blocks will range from $4-7/ha (Brinkman, 1989).

Area Base Plant

Bids
1989
Nipigon
- $444/ha or $222/M
Chapleau
- $375/ha or $231/M
North Bay
1) $578/ha or $462/M
2) $365/ha or $248/M
1990
Nipigon
- $485/ha or $328/M
Wawa
- $319/ha or $198/M
North Bay
1) $394/ha or $245/M
2) $447/ha or $235/M
3) $460/ha or $337/M

Total Cost to MNR
Nipigon - 1989
$484/ha or $284/M
North Bay - 1989
$552/ha or $418/M

Costs are approximations only based on estimated equipment and salary requirements.

BULK LIFT COSTS, FALL 1990

Assumptions

The bulk lift is a separate operation and there is no cross over between the bulk and the conventional lifts in terms of staff or equipment.

A standard work day is 8 hours with two 15 minute coffee breaks for a total of 7.5 working hours.

Rates for equipment are calculated from monthly rates by dividing rate by 26 working days per month and multiplying by the number of days used. (2.175 days for bulk lift)

A mechanic would be on hand for the same shift as the bulk harvester staff.

The bulk harvester was operated for 18 hrs 54 min. Of this time 5 hrs 12 min. was lost due to mechanical breakdowns. Total payable time was 17 hrs 24 min. which takes into account the three 30 minute lunch breaks.

Bulk lift costs

1) Root Pruning - 2 hours	
- tractor w/ vertical root pruner $8.00/hr	$ 16.00
- operator 1) RT2 $17.19/hr	$ 34.38
2) RT1 $15.58/hr	$ 31.16
	$ 81.54
2) Undercutting with belly blade	
- 2 hours (22 beds)	
- tractor w/ belly blade $8.00/hr	$ 16.00
- operator 1) RT2 $17.19/hr	$ 34.38
	$ 50.38
3) Bulk Lift - 17 hours 24 min	
- quality assessor RT1 $15.17/hr	$ 263.96
- minivan - $870/mo.	$ 72.78
- mechanic - 5 hours 12 min @ $18.40/hr	$ 95.68
- assistant - 5 hrs 12 min @ $17.19/hr	$ 89.39
- MNR staff at shipping barn RT1 $15.17/hr	$ 263.96
	$ 785.77

4) Contractor costs

- tractor w/ belt harvester; 17.9 hours		
- tractor $6.50/hr		$ 116.35
- harvester $4.50/hr		$ 80.55
- 2 machine operators @ $12.89/hr * 17.4hrs		$ 448.57
- manual workers (7) @ $12.89/hr		$1,570.00
- box makers (2) @ $12.89/hr		$ 448.57
- loader (1) @ $12.89/hr		$ 224.29
- unloaders (2) @ $12.89/hr		$ 448.57
- truck driver (1) @ $12.89/hr		$ 224.29
- supervisor (1) @ $15.46/hr		$ 269.00
- Benefits (UIC 1.4%, CPP 2.2%, EHB 1.95%, WCB 4.65%, tot= 10.2%)		$ 370.60
- Half ton pickup (1) rate $744/month + mileage + fuel = $800/mo.		$ 66.92
- Office Trailer ($160/mo.)		$ 13.38
- Portable Toilets ($100/mo.)		$ 8.36
- Telephone (install. $27 + $18/mo.)		$ 28.51
- Storage Vans for boxes ($175/mo. ea.)		$ 14.64
Contractor Cost		$4,332.00
- contractor's profit margin above costs - 30%	X 1.30	$5,631.60
Supplies		
- boxes 3.76 ea/4 yr = 0.94 ea/yr 173,757 - 931 boxes		$ 875.14
- liners $218/1000 173,757 - 931 boxes		$ 176.89
- staples		$ 54.88
Total Cost for bulk harvest		$7,656.20

Seedlings lifted:

Stock # 890034	640 boxes @203.12 seedlings/box =	129,997
Stock # 890033	291 boxes @163.75 seedlings/box =	47,651
		177,648

Total Cost per 1000 for 177,648 seedlings	$ 43.10
Without Estimated Contractor Profit Margin Total Cost	$6,356.60
Total Cost per 1000 for 177,648 seedlings	$ 35.78

Cost to Ministry for 1990 fall bulk lift

Payment to contractor for 195,624* seedlings @ $24.45/1000	$4,783.01
Less equipment rental costs	- $ 196.90
Root Pruning	$ 81.54
Undercutting with Belly blade	$ 50.38
MNR staff - includes mechanics' time	$ 785.77
Supplies - boxes, liners and staples	$1,106.91
	$6,610.71
Total Cost per 1000 for 177,648 seedlings	$ 37.21

*Based on Nursery's in-bed inventory total # of seedlings = 195,624

Cost Analysis of the Fall Bulk Lift - Area Base Plant.

Bulk Lift

Undercutting
Total Cost $50.38
$0.28/1000

Root Pruning
Vertical
Total Cost $81.54
$0.46/1000

Seedlings Lifted
- 177,648

MNR Costs
Total Cost $785.77
$4.42/1000

CONTRACTOR COSTS w/ 30% Profit Margin
Total Cost $5,631.60
$31.70/1000

Actual Payment to Contractor by MNR
$4,586.11
$25.82/1000

SUPPLIES
Boxes - $4.93/1000
Liners - $1.00/1000
Staples - $0.31/1000

TOTAL COSTS
- based on estimate of contractor's cost plus profit margin
  $7,524.28
  $42.35/1000
- based on actual payment by MNR
  $6,478.79
  $36.47/1000

Shipping

Cooler

- changes in shipping cost will depend on the number of seedlings in a box.
- if less than number per box for conventional lift then shipping bulk lifted stock will cost more.

Planting Site

Pre Plant Assessment

Costs for Pre plant Assessment should be similar for both planting payment systems.
Costs to the contractor for laying out the planting blocks will range from $4-7/ha (Brinkman 1989).

Area Base Plant

Bids
1989
Nipigon
- $444/ha or $222/M
Chapleau
- $375/ha or $231/M
North Bay
1) $578/ha or $462/M
2) $365/ha or $248/M
1990
Nipigon
- $485/ha or $328/M
Wawa
- $319/ha or $198/M
North Bay
1) $394/ha or $245/M
2) $447/ha or $235/M
3) $460/ha or $337/M

Total Cost to MNR
Nipigon - 1989
$484/ha or $284/M
North Bay - 1989
$552/ha or $418/M

Costs are approximations only based on estimated equipment and salary requirements.

APPENDIX IX

Fall Bulk Lift Costs

for Compartments 48 and 58

BULK LIFT COSTS, FALL 1990
COMPARTMENT 48

Assumptions

The bulk lift is a separate operation and there is no cross over between the bulk and the conventional lifts in terms of staff or equipment.

A standard work day is 8 hours with two 15 minute coffee breaks for a total of 7.5 working hours.

Rates for equipment are calculated from monthly rates by dividing rate by 26 working days per month and multiplying by the number of days used. (0.36 days for bulk lift of compartment 48)

A mechanic would be on hand for the same shift as the bulk harvester staff.

This analysis assumes no mechanical breakdowns.

Bulk lift costs

1) Root Pruning - 0.5 hours for 5 beds	
- tractor w/ vertical root pruner $8.00/hr	$ 4.00
- operator 1) RT2 $17.19/hr	$ 8.60
2) RT1 $15.58/hr	$ 7.79
	$ 20.39
2) Undercutting with belly blade	
- 0.5 hours (5 beds)	
- tractor w/ belly blade $8.00/hr	$ 4.00
- operator 1) RT2 $17.19/hr	$ 8.60
	$ 12.60
3) Bulk Lift - 2 hrs 55 min	
- quality assessor RT1 $15.17/hr	$ 44.25
- minivan - $870/mo.	$ 12.05
- MNR staff at shipping barn RT1 $15.17/hr	$ 44.25
	$ 100.55

4) Contractor costs

- tractor w/ belt harvester; 3.41667 hours		
- tractor $6.50/hr		$ 22.21
- harvester $4.50/hr		$ 15.37
- 2 machine operators @ $12.89/hr	* 2.91667 hrs	$ 75.20
- manual workers (7) @ $12.89/hr		$ 263.20
- box makers (2) @ $12.89/hr		$ 75.20
- loader (1) @ $12.89/hr		$ 37.60
- unloaders (2) @ $12.89/hr		$ 75.20
- truck driver (1) @ $12.89/hr		$ 37.60
- supervisor (1) @ $15.46/hr		$ 45.09
- Benefits (UIC 1.4%, CPP 2.2%, EHB 1.95%, WCB 4.65%, tot= 10.2%)		$ 73.63
- Half ton pickup (1) rate $744/month + mileage + fuel = $800/mo.		$ 11.08
- Office Trailer ($160/mo.)		$ 2.22
- Portable Toilets ($100/mo.)		$ 1.38
- Telephone (install. $27 + $18/mo.)		$ 27.25
- Storage Vans for boxes ($175/mo. ea.)		$ 2.42
Contractor Cost		$ 764.65
- contractor's profit margin above costs - 30%	X 1.30	$ 994.05
Supplies		
- boxes 3.76 ea/4 yr = 0.94 ea/yr 47,651 - 291 boxes		$ 273.54
- liners $218/1000 47,651 - 291 boxes		$ 63.44
Total Cost for bulk harvest		$1,464.57
Total Cost per 1000 for 47,651 seedlings		$ 30.74

Without Estimated Contractor Profit Margin

Total Cost	$1,235.17
Total Cost per 1000 for 47,651 seedlings	$ 25.92

BULK LIFT COSTS, FALL 1990
COMPARTMENT 58

Assumptions

The bulk lift is a separate operation and there is no cross over between the bulk and the conventional lifts in terms of staff or equipment.

A standard work day is 8 hours with two 15 minute coffee breaks for a total of 7.5 working hours.

Rates for equipment are calculated from monthly rates by dividing rate by 26 working days per month and multiplying by the number of days used. (1.16 days for bulk lift of compartment 58)

A mechanic would be on hand for the same shift as the bulk harvester staff.

This analysis assumes no mechanical breakdowns.

Bulk lift costs

1) Root Pruning - 1.5 hours for 17 beds	
- tractor w/ vertical root pruner $8.00/hr	$ 12.00
- operator 1) RT2 $17.19/hr	$ 25.79
2) RT1 $15.58/hr	$ 23.37
	$ 61.16
2) Undercutting with belly blade	
- 1.5 hours (17 beds)	
- tractor w/ belly blade $8.00/hr	$ 12.00
- operator 1) RT2 $17.19/hr	$ 25.79
	$ 37.79
3) Bulk Lift - 9 hrs 17 min	
- quality assessor RT1 $15.17/hr	$ 140.83
- minivan - $870/mo.	$ 38.82
- MNR staff at shipping barn RT1 $15.17/hr	$ 140.83
	$ 320.48

4) Contractor costs

- tractor w/ belt harvester; 10.2833 hours		
- tractor $6.50/hr		$ 66.84
- harvester $4.50/hr		$ 46.27
- 2 machine operators @ $12.89/hr	* 9.2833 hrs	$ 239.32
- manual workers (7) @ $12.89/hr		$ 837.64
- box makers (2) @ $12.89/hr		$ 239.32
- loader (1) @ $12.89/hr		$ 119.66
- unloaders (2) @ $12.89/hr		$ 239.32
- truck driver (1) @ $12.89/hr		$ 119.66
- supervisor (1) @ $15.46/hr		$ 143.52
- Benefits (UIC 1.4%, CPP 2.2%, EHB 1.95%, WCB 4.65%, tot= 10.2%)		$ 197.72
- Half ton pickup (1) rate $744/month + mileage + fuel = $800/mo.		$ 35.69
- Office Trailer ($160/mo.)		$ 7.14
- Portable Toilets ($100/mo.)		$ 4.46
- Telephone (install. $27 + $18/mo.)		$ 27.80
- Storage Vans for boxes ($175/mo. ea.)		$ 7.81
	Contractor Cost	$2,332.17
- contractor's profit margin above costs - 30%	X 1.30	$3,031.82

Supplies

- boxes 3.76 ea/4 yr = 0.94 ea/yr 129,997 - 640 boxes	$ 601.60
- liners $218/1000 129,997 - 640 boxes	$ 139.52
Total Cost for bulk harvest	$4,192.37
Total Cost per 1000 for 129,997 seedlings	$ 32.25

Without Estimated Contractor Profit Margin

Total Cost	$3,492.72
Total Cost per 1000 for 129,997 seedlings	$ 26.87

APPENDIX X

Conventional and Area Base Planting Costs

CONVENTIONAL AND AREA BASE PLANTING COSTS

Conventional Plant

Thunder Bay 1989/90 - tree planting costs. (includes all costs charged to tree planting codes (4421) including assessment plot establishment)

Bare-root
- 572 ha, 1,377,400 trees
- A salary 1,100; B salary 24,600; TCSS&E 276,300; Total $302,000
- $527.97/ha - $219.25/1000 trees

Container
- 141.6 ha, 320,800 trees
- A salary -; B salary 7,000; TCSS&E 60,600; Total $67,600
- $477.40/ha - $210.72/1000 trees

Total
- 713.6 ha, 1,698,200 seedlings
- A salary $1,100; B salary $31,600; TCSS&E $336,900; Total $369,600
- $517.94/ha - $217.64/1000

Nipigon (1990) - avg. bid price $225.00/1000 trees (D. Jackson)

North Central Region (1990) - avg. payment to contractor $198.00/1000 seedlings. (B. James)

Area Base Plant

1989 Nipigon - bid $444.00/ha - $222.00/1000
100 ha - 170,340 trees (200,000 trees originally).
MNR Cost including A and B Salaries and TCSS&E
- $483.73/ha - $283.98/1000
w/o A Salary $463.48/ha - $272.09/1000
similar per tree contract conducted in same year on site close to area base. Bid - $244/1000 - $488/ha

Chapleau - bid $375/ha - $233.41/1000

North Bay - bid area 1) $578/ha - 462.40/1000
area 2) $365/ha - 248.20/1000
area 1) 72 ha - 140,000 trees total 2 areas
2) 34 ha -
MNR cost incl. Salaries and TCSS&E
total both areas $552.18/ha - $418.08/1000
w/o A salary $545.50/ha - $413.02/1000

1990 Nipigon - bid $485.00/ha - $327.84/1000 Planters paid by tree.
Actual payment to contractor - $448.37/ha
461,200 seedlings planted on 283.9 ha
Payment to contractor - $276.00/1000 seedlings.
This was the highest in the NCR in 1990.

Wawa - Doug Hunter indicated that on a per 1000 seedling basis area base plant was cheaper. Planters paid by hour.
Working on report.
bid - $318.64/ha - 37.3ha - 60,000 seedlings
- $198.09/1000.

North Bay - 3 areas. bids
1) 101 ha - $393.55/ha
162,000 trees - $245.36/1000
2) 60 ha - $446.75/ha
114,000 trees - $235.13/1000
3) 33 ha - $460.24/ha
45,125 trees - $336.59/1000

No report. Planters paid by area.
Bob Brunette indicated that area base was more expensive.
This was for two reasons.
1) lack of competitive bidding.
2) used system on most difficult sites, therefore higher cost.